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ABSTRACT

Since the inception of "GOALS 2000: Educate America Act" (1994), the nation at large has been implementing standards for systematic reform. Teachers and teacher candidates must become "techno-savvy" overnight in order to comply with these reform initiatives as their level of expertise in educational technology will ostensibly affect their lesson planning and their students' involvement with the global highway. It is believed that the level of technology skills is embryonic and not in sync with ISTE standards. There is no "bell shaped curve" on the continuum of "techno-savvy" teachers--the majority of teachers and teacher candidates nationwide are in the rudimentary stages. Using current educational standards and theoretical frameworks, a pragmatic model called "Constructual Multi-Modalities Model for MST Inquiry Units" has been developed. The goals for teachers/teacher candidates include: (1) to acquire the skills and knowledge required of a competent and pragmatic pedagogue in the information age in the teaching of elementary school mathematics, science, and technology; (2) to experience through hands-on activities how the disciplines of mathematics and science are integrated and can be enhanced through the highly motivational medium of technology; and (3) to construct their own math-science-technology (MST) Science Inquiry Units in order to turnkey the skills and strategies they master to their prospective students. (Author/MVL)

# S.U.N.Y. STUDENTS SUCCESSFULLY INTEGRATE MATHEMATICS AND TECHNOLOGY IN THE INTERMEDIATE ELEMENTARY SCIENCE INQUIRY CLASSROOM



Paper presented at American Educational Research Association
Chicago, New York
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## Introduction

Since the inception of "GOALS 2000: Educate America Act" (1994) the nation at large has been implementing standards for systematic reform. Compounded by the technology revolution in pedagogy and industry, legislators across America have required State Education Departments to create content standards and accountability measures that reflect the chameleonic tools of technology. Teachers and teacher candidates must become *"techno-savvy"* overnight in order to comply with these reform initiatives, as their level of expertise in educational technology will ostensibly affect their lesson planning and their students' involvement with the global highway (O'Connor-Petruso, 2002).

As an instructor of technology for the past decade for both pre-service and graduate level teachers (K-12), I can unequivocally state that the level of technology skills is embryonic and not in sync with ISTE Standards. There is no "bell shaped curve" on the continuum of "*techno-savvy*" teachers–the majority of our teachers and teacher candidates "nationwide" are in the rudimentary stages. I have also found that "math phobia" remains steadfast and the notion of "viewing and experiencing" mathematics and science as integrated cores in the classroom is fleeting as instructional models that integrate the cores do not exist.

Using current educational standards and theoretical frameworks, I have developed a pragmatic model "Constructual Multi-Modalities Model for MST Inquiry Units" (O'Connor, 2001a) that addresses the aforementioned quandary. As an Assistant Professor of Mathematics, Science, and Technology at S.U.N.Y. College at Old Westbury, I show teachers and teacher candidates how to a) help each other learn technology, and b) integrate mathematics and technology in the intermediate elementary science inquiry classroom (O'Connor-Petruso, 2003). Special emphasis is placed on incorporating student activities that address the science content and manipulative skills of the Fourth Grade New York State Program Evaluation Test (PET) in Science (formerly the ESPET).

My goals for teachers/teacher candidates are as follows: 1) To acquire the skills and knowledge required of a competent and pragmatic pedagogue in the "information age" in the teaching of elementary school mathematics, science, and technology, 2) To experience through "hands-on" activities that the disciplines of mathematic and science are integrated and can be enhanced through the highly motivational medium of technology (Bates, 2000; O'Connor, 1999) and 3) To "construct" their own MST Science Inquiry Units in order for them to "turnkey" the skills and strategies they mastered to their prospective students.

### C. M. M. Model for MST Science Inquiry Units (O'Connor, 2001)

The Constructural Multi-Modalities Model for MST Science Inquiry Units is designed for classroom teachers and provides a pragmatic approach to integrate mathematics and technology in the intermediate (Grades 4-6) elementary science inquiry based classroom (see Figure 1). It is grounded in the learning theories of Benjamin Bloom (1956) and Howard Gardner (1993). The MST Model utilizes an interdisciplinary (Jacobs, 1989) and constructivist (Bodner, 1986; Vygotsky, 1981) approach to instruction and addresses the following science inquiry units (Peters & Gega, 2002) to be taught in the intermediate elementary classroom: 1) Light, Energy, and Color, 2) Heat Energy, 3) Sound Energy, 4) Magnetic Interactions, 5) Electrical Energy, 6) Simple Machines, 7) Plant Life, 8) Animal Life, 9) The Human Body and Nutrition, 10) The Earth's Changing Surface, 11) Water, Air, and Weather, and 12) The Earth in Space.

The MST model begins with a "Holistic Guiding Question" from the selected inquiry unit to spur student curiosity and prompt their need to discover. For example, *"How does light travel and can I see it?"* is an engaging student prompt for the inquiry unit on Light, Energy and Color. The individual classroom teacher then decides or constructs (based upon their specific behavioral goals and their understanding of the MST benchmarks) what the "holistic guiding question" will be and what specific venue the nine required lessons in each inquiry unit will take in terms of content standards, integrating various math, science, and technology skills, and incorporating student assessments that reflect differentiated learning styles. Venue, in the constructivist approach, refers to the series of behavioral objectives and corresponding "hands–on" student activities the classroom teacher "facilitates" in the classroom to keep students actively engaged in the learning process – in the discovery of new science concepts.

To address the needs of our student's "differentiated learning styles" and P.L. 105.17: Individual Disability's Education Act (IDEA '97), Gardner's "Multiple Intelligences" are implemented in the inner ellipse of the MST model's infrastructure. By focusing on a wide spectrum of abilities, the *Theory of Multiple Intelligences* builds upon students' strengths and an array of curricular activities where students can have the opportunity to excel. Concurrent research (Byrne & Shavelson, 1986; Slavin, 1997; Taylor & Michael, 1991) has long acknowledged the positive correlation between student self-esteem and achievement.

The nine intelligences to be addressed in terms of student activities and assessments are: (1) verbal/linguistic, (2) logical/mathematical, (3) visual/spatial, (4) bodily/kinesthetic, (5) musical/rhythmic, (6) interpersonal, (7) intrapersonal, (8) naturalist and (9) existentialist. The following table (see Table 1) cites an abbreviated list of suggested student activities per each intelligence:

**Table 1: Student Activities for Differentiated Learning Styles** (O'Connor, 2001)

| | |
|---|---|
| (1) | **verbal/linguistic:** storytelling, lectures, group discussions, debates, word games, writing activities, using word processors, newsletters, journals, choral reading, extemporaneous speaking , listening, individualized reading, reading to the class, taping one's words et al. |
| (2) | **logical/mathematical:** problem solving, scientific method, Socratic questioning, classifications and categorizations, sequencing, reasoning, analysis, puzzles, games, codes, calculators, and software programs and games that address problem solving exercises et al. |
| (3) | **visual/spatial:** organizing information, tables, charts, graphs, diagrams, maps, icons, illustrations, photography (digital camera), slideshow productions, .mpeg productions, visual arts (collages, painting, drawing, designing, diorama's), telescopes, microscopes, binoculars, visual organizers (Venn Diagrams), and graphic software programs (Inspiration) et al. |
| (4) | **bodily/kinesthetic:** creative movement, dance, the classroom theatre, "hands-on" activities, choral reading, games, mime, crafts, body maps, manipulatives, tactile materials, kinesthetic activities, and virtual reality software. |
| (5) | **musical/rhythmic:** musical expression, songs, rap, chants, choral reading, humming, whistling, musical instruments, rhythms, patterns, creating new melodies, musical appreciation, discographies, and musical software. |
| (6) | **interpersonal:** people orientated activities, apprenticeships, cooperative activities (research projects), pair activities (peer sharing/mentoring, "*techno-savvy*" pairs), academic clubs, community involvement, and interactive software. |
| (7) | **intrapersonal:** intuitive activities, independent self-paced activities (journals, poetry), independent work stations, self-esteem assignments, and computer assisted instruction (CAI) software. |

| | |
|---|---|
| (8) | **naturalist:** classroom without walls: outdoor activities, collecting live samples (probes) for the inquiry based classroom, "hands-on" experiences with various kingdoms (animal and plant) and topographies (streams, lakes, hills, valleys), field trips, and scientific software that allows for analysis of the student's outdoor data collection. |
| (9) | **existentialist:** research projects and activities that show the value of human input in the world, field trips (virtual and live) to diversified organizations (NYMASLI: New York Metropolitan Area Service Learning Institute, Volunteer Programs, United Nations, Peace Corps), engaging local politicians and agencies in ecological issues, and student involvement with other classrooms (via internet: e-mail and/or videoconferencing) on major mathematical and scientific concerns (such as the Jason Project). |

The outer ellipse of the MST Model adheres to the cognitive domain of Bloom's Taxonomy (1956) where each of the nine required lessons are sequential and address specific multiple intelligence(s). Although lesson planning is sequential, there is no "preset order" to addressing the nine student intelligences (as defined by Gardner) within the MST inquiry unit. Each classroom teacher decides or constructs which student assessment is the best fit for the prescribed behavioral objective and corresponding activity (see "Sampling" of Student Assessments within Chart 1).

**MST Lesson Plan Format (O'Connor, 2001)**

Every lesson plan adheres to the recommendations of the National Council of Teachers of Mathematics (2000), the National Research Council (2000), ISTE'S National Educational Technology Standards for Students (2002), the New York Standards (2000), and the MST Lesson Plan Format (O'Connor, 2001b) see Figure 2. There are a minimum of nine sequential lessons congruent with Bloom's Taxonomy within each unit. Each lesson plan has its unique title and will "earmark" a specific intelligence as evinced through student activities and assessments (see Appendix A: Sample Lesson Plan "Plant Detectives").

Each lesson plan lists the level(s) of Bloom's Taxonomy each behavioral objective is attempting to achieve. Behavioral objectives with a listing of congruent verbs and diversified student activities are also listed on Chart 1 "Sampling of Student Assessments for the Constructural Multi-Modalities Model for Elementary MST Science Inquiry Units (O'Connor-Petruso, 2002).

Cognizant of declining and or/unstable test scores in mathematics and science, and of the students' unfamiliarity in experiencing the interrelatedness between the two cores, special emphasis is placed on incorporating student activities that address the mathematics "process standards" and the "content standards" as devised by the National Council of Teachers of Mathematics (2000), and to the science content and "inquiry skills" as recommended by the National Research Council NRC (2000), and to the "manipulative skills" performance section of the Fourth Grade New York State Program Evaluation Test (PET), formerly the ESPET.

The five focus areas of the mathematic "process standards" are 1) problem solving , 2) reasoning and proof, 3) communication, 4) connection, and 5) mathematical representations. The five "content standards" are 1) numbers and operations, 2) algebra, 3) geometry, 4) measurement, and 5) data analysis and probability.

The specific science "inquiry skills" to be implemented in the elementary classroom are 1) observation, 2) estimation, 3) classification, 4) measurement, 5) communication, 6) inference, 7) hypothesizing, and 8) experimentation. In New York State the science process skills of the Elementary Science Core Curriculum (2000) incorporate Standards 1, 2, 6, and 7 of the *Learning Standards for Mathematics, Science, and Technology* (1996).

Behavioral objectives are then cross-referenced with Mathematics Skills (NCTM, 2000) and Science Inquiry Skills (NRC, 2000) to a) ensure that each of the mathematics process and content standards are being covered in class, and b) to have students "discover" that mathematics is integral to our world through a system of patterns, relations, and logical functions as evidenced in our science inquiry skills. For example in Lesson #2: "Plant Detectives"(see Appendix A), the mathematics process standards of reasoning, proof, and connections are integrated with the science inquiry skills of observation, classification, communication, and inference which are cumulatively needed to produce the successful student implementation of "numbers and operations; data analysis and probability (mathematics content standards)."

In addition, behavioral objectives for five out of the nine lesson plans focus on "one" of the manipulative skills of the N.Y.S. Fourth Grade Performance Evaluation Test (DeMauro, 1999). The manipulative skills are designed to assess a number of inquiry, problem solving, and communication skills contained in N.Y.S. Elementary Science Core Curriculum (2000), and the N.Y.S. Learning Standards for Mathematics, Science, and Technology [elementary level] (1996). These "hands-on" tasks (see Chart 2) actively engage students in the "discovery process" by providing them with opportunities to have direct experience with objects and materials in the natural world and utilize their critical thinking skills to construct their own meaning /explanations about various scientific concepts and theories. Figure 3 shows how students can use an inexpensive voltmeter, available at most hardware stores ($10-20), to test the hypothesis that fruit (in conjunction with copper and zinc) can act as batteries and conduct electricity by testing each fruit's dilute acidity level.

**Chart 2: Manipulative Skills of Fourth Grade N.Y.S. Program Evaluation Test (PET)**

| | | |
|---|---|---|
| Task #1 | Liquids | Students use measurement tools, observation, and inference skills to determine the physical properties of objects. |
| Task #2 | Grouping Objects | Students use classification skills to create groups and subgroups |
| Task #3 | Ball & Ramp Game | Students work cooperatively (in pairs) to gather data to create a 'ball & ramp game' which involves measuring distance, inference, and making predictions. |
| Task #4 | Magnetic & Electrical Testing | Students use a magnet and electrical tester to collect data, record findings, and make inferences on the magnetic & electrical properties of a set of objects. |
| Task #5 | Unknown Object | Students are asked to identify an unknown object using observational skills and nonstandard forms of measurement, and list additional scientific questions. |

Each of the nine multiple intelligences are addressed at least once (at a minimum) throughout the unit. Although lesson planning is sequential, there is no "preset order" to addressing the nine student intelligences within the MST inquiry unit. However, the suggested guideline for addressing diversified intelligences should be no more than "three stated intelligences" per lesson plan as the teacher/teacher candidate must provide for a specific student activity and assessment per each stated intelligence in the lesson plan. Each classroom teacher decides or constructs which student assessment is the best fit for the prescribed behavioral objective and corresponding activity.

Acknowledging our pluralistic society and continued rise in English as a Second Language Learners (ESLL) each lesson plan incorporates a selection of children's literature. The selections are to include diversified mediums including online selections of textbooks, newspapers, articles, poems, encyclopedias, online databases et al.

Additional behavioral objectives (initial echelon of Bloom's Taxonomy: knowledge, comprehension, and application) can be introduced at any point in the inquiry unit as soon as student mastery of previous behavioral objectives occurs. However it is critical that the goals of lesson plans #'s 5-9 engage students in Bloom's "critical thinking skills" of analysis, synthesis, and evaluation as international data shows (NCES, 2001) weak student performance in these areas. In sync with the standards, classroom teachers need to create more lessons that hone students' higher order thinking skills.

Similarly, the introduction of graphic organizers and the student created Web page in specific lessons (lesson #'s 4 and 5) are only a suggestion. Each classroom teacher in the constructivist approach decides where and when (venue) to implement these activities. In the constructivist approach (a compilation of the theories of Bruner (1966), Piaget (1954), Vygotsky (1981), - among others), the role of the classroom teacher is primarily to "facilitate and guide," and to provide a variety of resources and differentiated activities to keep the students "on task and active" in the learning process. Classroom teachers should focus on making connections between facts and fostering new understanding in students by encouraging students to use their critical thinking skills. With the advent of technology, students can literally construct/build their own learning constructs as evinced in their creation of multimedia products, Web pages et al.

Within the procedures section of the lesson plan, teachers and teacher candidates should prepare two closed-ended (objective) questions with answers and two open-ended (subjective) questions. Both types of questions are utilized because they incorporate direct instruction and constructivism. Closed-ended questions elicit definitive responses which are in direct relation to behavioral objectives. Open-ended questions engage the students in alternative explanations which in turn provide a venue for the utilization of higher order thinking skills of analysis, synthesis, and/or evaluation – the upper echelon of Bloom's Taxonomy.

To prepare for each lesson, teachers and teacher candidates must also refer to the state learning standards and district guidelines in terms of content, concepts and skills to be mastered. Benchmarks and performance indicators within each standard are used to assess student understanding of behavioral objectives and help teachers set rubrics to evaluate student progress and products. Each lesson plan must incorporate an assessment rubric with plausible student answers. Two practical examples are provided in Appendix A: Sample Lesson Plan "Plant Detectives" [(1)] and entitled "Rubric A - A Nature Walk Rubric with Student Sample Collage and

Sample Student Rubbings/Etchings," and "Rubric B - Mathematical Representation: Three Vein Patterns of Leaves." The assessment methods utilized in the MST inquiry unit include a "portfolio" of diversified activities that reflect the nine multiple intelligences. The benefits of multiple assessments are well documented (Asp, 2000).

Additional components of the MST Science Inquiry Unit include lesson plans that actively promote student problem solving, inquiry, and higher order critical thinking skills. These "hands-on" activities include student use of a) graphic organizers for classifying, comparing and contrasting, and communicating, and b) spreadsheets and graphs [bar, line or circle/picto graph] for practice in the skills of mathematical representation, measuring, inference, interpreting data, and experimentation, and c) scavenger hunts/WebQuests for problem solving, predicting, and making decisions.

In the true spirit of the constructivist approach, classroom teachers opt for the venue of showing students how to create and construct a multimedia product such as a PowerPoint Presentation or a personal Web page (template) on "student understanding" of the science concept to be learned. A proven 'motivator' to stimulate your students' natural curiosity is to demo your own PowerPoint Presentation on key points of the MST inquiry unit (see Sample PowerPoint presentation on the MST inquiry unit "Plant Life" in Handouts View: Appendix B and on my website http://triton.oldwestbury.edu/~oconnors. A suggested criterion for the PowerPoint presentation is also available in Table 1

***Web-based Tools for MST Units***

Although there is a legion of software products on the commercial market, this model advocates various "user-friendly" software tools and the use of Microsoft Office (MS Word, MS Excel, MS PowerPoint) because it is the popular tool of choice in both industry and pedagogy and is readily available in most educational institutions and public libraries. Acknowledging the "Internet Divide" (OECD, 2001), MST teachers "must" use the tools of technology that are accessible to all students. The following tools of technology were chosen due to their motivational capabilities, "user-friendliness," and economic practicality. Suggested software for the graphic organizer is Inspiration as it is extremely "user-friendly" and allows the user to create two views simultaneously: diagram view and text view. Free trial versions can be downloaded from their homepage (www.inspiration.com/home.cfm). In terms of graphic software, I like MS Excel and Tom Snyder's "The Graph Club" due the aforementioned reasons. Students can download free thirty-day trial versions from Tom Snyder's homepage (www.tomsnyder.com). Examples of various scavenger hunts/WebQuests and an opportunity to create your own Web page (ample megabytes of free space) of hyperlinks can be found on a SBC Pacific Bell sponsored site, (www.filamentalty.com/), entitled "Knowledge Network Explorer." The Filamentality site is a "step-by-step" template. It is interactive, user-friendly, and a wonderful introduction for *"non-techno-savvy"* users to create their first Web page.

## Conclusion

The benefits of integrating mathematics and technology in the elementary science inquiry classroom are well-documented (NCTM, 2000; NRC, 2000) as these cores necessitate student higher order thinking skills. The highly motivational medium of technology (Bates, 2000) not only promotes constructivism but also lends itself to active "hands-on" problem solving activities which are essential to the inquiry process for scientific literacy. Thus it is incumbent upon classroom teacher to keep abreast of new curricular approaches and models involving the tools of technology in order to prepare lessons that promote critical thinking skills.

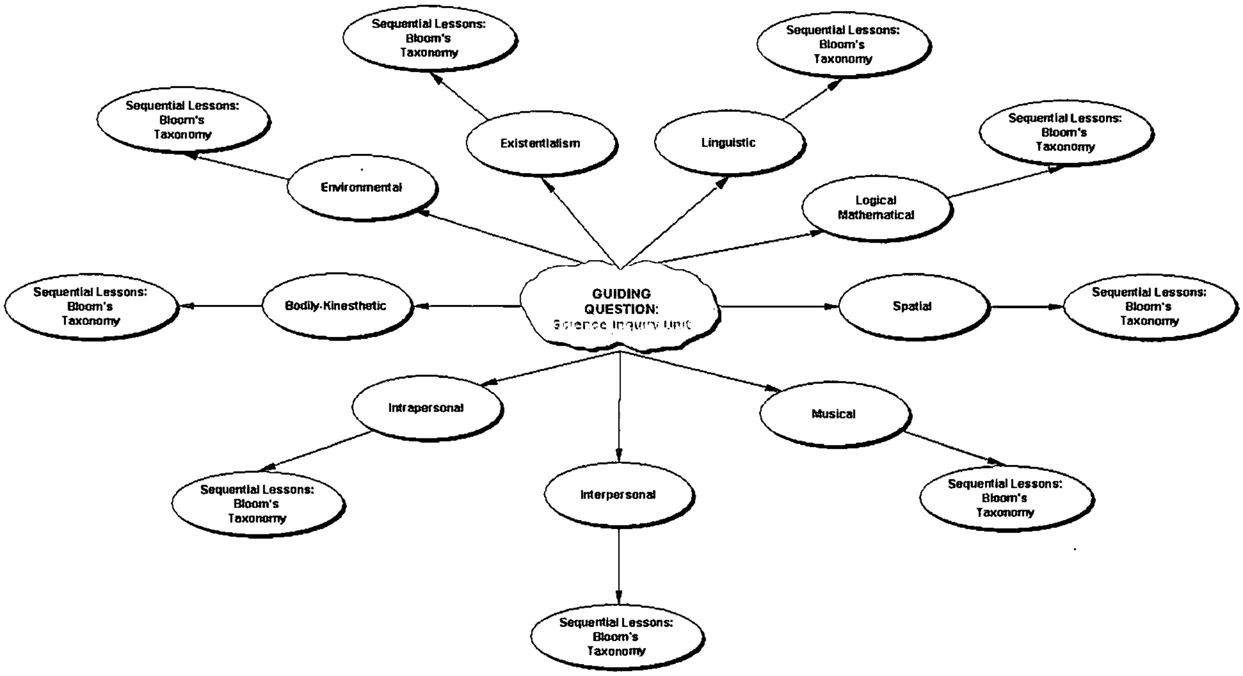
The C.M.M. Model for MST Inquiry Units (O'Connor-Petruso, 2003) is a pragmatic and "user friendly" paradigm for showing teachers and teacher candidates strategies on how to create lesson plans that integrate the three cores in tandem, adhere to the state standards, and actively engage their students' differentiated learning styles through multiple activities. If classroom teachers start modeling (Hunter, 1984) and implementing technology in the elementary grades, they will be preparing their students for the "information age" where the tools of technology are no longer a personal choice but an educational necessity for "success stories" in student productivity (Dewey, 1916).

Please see my website, http://triton.oldwestbury.edu/~oconnors, for examples of exemplary lesson plans and filamentality websites on diversified MST Inquiry Units created by our teacher candidates at S.U.N.Y. College of Old Westbury.

## FIGURE 1

### THE CONSTRUCTURAL MULTI-MODALITIES MODEL MST INQUIRY UNITS

*MST Model: O'Connor, 2001*




**CONSTRUCTURAL MST MULTI-MODALITIES MODEL**
**FOR MST SCIENCE INQUIRY UNITS**

**Central ellipse: Motivational prompt: a holistic "GUIDING QUESTION" from one of the twelve science inquiry units.**

**Inner circle of ellipses: Addresses Howard Gardner's Nine Multiple Intelligences.**

**Outer circle of ellipses: Utilizing the specific multiple intelligence(s), nine MST sequential lesson plans that adhere to Bloom's Taxonomy and address the NYS Math, Science, & Technology Standards are constructed. Each "techno-savvy" pair design "five" of the nine lessons to include the manipulative skills of the Grade Four Performance Test: liquids, grouping objects, ball & ramp game, magnetic & electrical testing, and unknown object.**

**Lesson 1: Motivation - Knowledge**
**Lesson 2: Building MST Context Knowledge - Comprehension**
**Lesson 3: Reading Scientific fiction, Nonfiction or Empirical Data- Comprehension, Application**
**Lesson 4: Retelling Comprehension - Application**
**Lesson 5: Research Project - Application, Analysis**
**Lesson 6: Retelling the Research - Analysis, Synthesis**
**Lesson 7: Retelling the Research - Analysis, Synthesis (Alternate form of assessment)**
**Lesson 8: Reflection on Learning - Synthesis, Evaluation**
**Lesson 9: Taking Action, Going Beyond the Classroom to Share the Interdisciplinary Unit - Synthesis, Evaluation (Third form of assessment)**

***Additional components of the MST Science Inquiry Unit include: graphic organizer(s), three spreadsheets with congruent graphs, WebQuest(s), personal Web page(s), and a PowerPoint presentation on the tenets of the interdisciplinary MST Inquiry Unit.**

***All Mathematics, Science, & Technology (MST) Lesson Plans adhere to the NYS Learning Standards for Mathematics, Science, & Technology, the NCTM (2000) and NRC (2000) Standards, and the ISTE National Educational Technology Standards (2000) for Students.**

**FIGURE 2**

## MST LESSON PLAN FORMAT

*O'Connor, 2001*

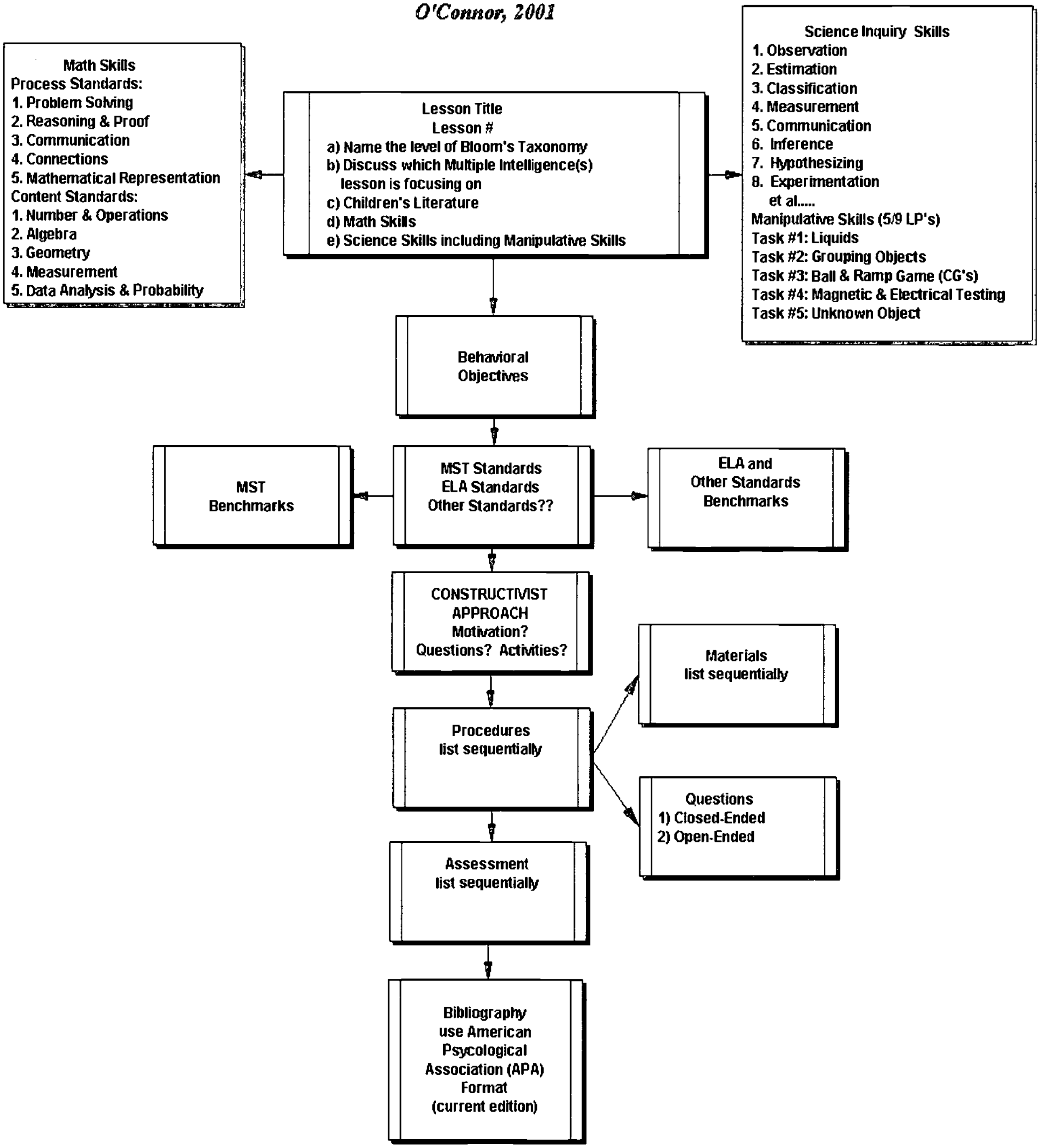


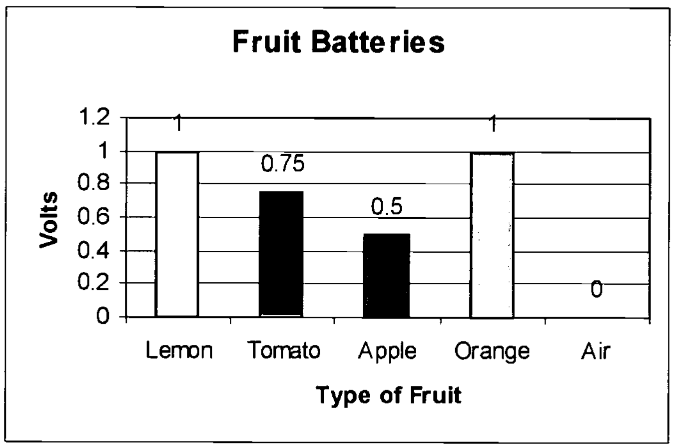
**Figure 3** [1]

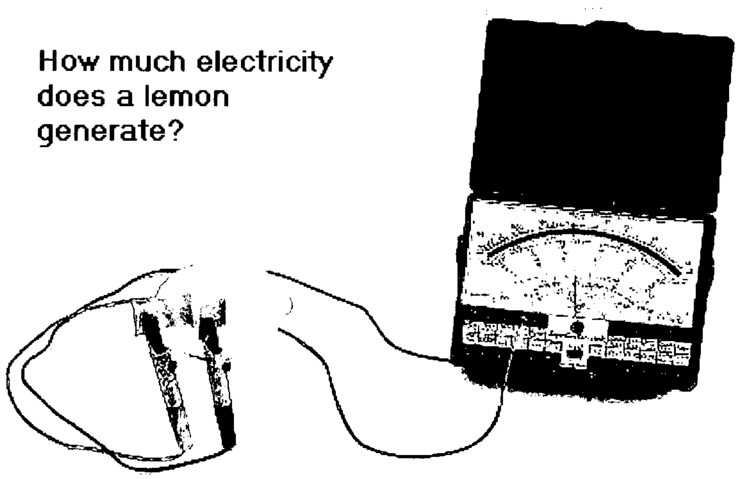
**Scientific Investigation on Magnetic and Electrical Testing (Manipulative Skills #4) of Fruit**

**Behavioral Objectives:**

1. To test the hypothesis that fruit can act as batteries.
2. To use the scientific method in conducting a "scientific investigation."
3. To create an Excel spreadsheet and congruent graph on the results of the experiment.

| Lemon | Tomato | [illegible] | Orange | Air |
|---|---|---|---|---|
| 1 | 0.75 | 0.5 | 1 | 0 |




**Materials:** Voltmeter, five strips of copper and zinc, two cables with alligator clips, and fruit.

*(Table and graph created with the software "Excel: " MS Office, 2002)*

(1) Portions of this lesson are from the MST Science Inquiry Unit "Plant Life" created by

**Table 1**

**Suggested Requirements for**

**PowerPoint Presentation of MST Science Inquiry Unit**

1. Culling the best from your MST unit, present a minimum of 10 slides.
   a. *Engage* your audience immediately with a captivating first slide: includes sound, pictures, animations and a memorable title.
   b. Discuss highlights (can be your top lessons /student activities/top behavioral objectives et al.) of your MST Inquiry Unit.
2. Include key aspects of at least four lessons.
   a. Include key aspects of at least one manipulative skills lesson plan.
   b. Include key aspects of at least one spreadsheet/table ➔ graph.
   c. Include highlights of the scavenger hunt.
   d. Include highlights of lesson focused on using a graphic organizer.
3. Include a hyperlink to your Filamentality Site.
4. Include sound: either supplied or download selections from your favorite .midi or .wav files.
5. Include a mixture of pictures and animations: .jpegs, .gifs., and .mpegs.
6. Include resources, online museums, videos, music, interactive sites et al.
7. *Remember:* "the more perceptual modalities you implement in your PowerPoint Presentation - the more motivated your audience will be to listen, engage, and learn!"
8. Your choice …Be Creative…Be Constructivists….

**Chart 1: Sampling of Student Assessments for Constructural Multi-Modalities Model for Elementary MST Science Units (O'Connor-Petruso, 2002)**

| **Sequential Lesson Planning (#1-#9)** | **Levels of Bloom's Taxonomy** | **Behavioral Objective(s)** | **Student Activities "To verb....** | **A "Sampling" of Student Assessments** (Dependent upon Multiple Intelligence(s) Lesson is Geared to) |
|---|---|---|---|---|
| **#1: Motivation** | Knowledge (Level 1) | * Begins with holistic motivating activity(ies).<br>* Subsequent goals include recalling of previously learned information. | enumerate, identify, label, list, recall, match, read, name, reproduce, tally, order, state view... | KWL Chart, fact tile, graphic organizers (Venn Diagram, software: ie Inspiration), videotape, filmstrip, diorama, mobile, crossword puzzle, test, newspaper... |
| **#2: Building MST Contextual Knowledge** | Comprehension (Level 2) | * The students understanding of the informational materials of the inquiry unit is evinced through the adjacent student activities. | explain, translate, describe, discuss, chart, estimate, generalize, justify, dramatize, provide examples... | KWL chart, Graphic organizer (Venn Diagram, graphic software), Flip Chute, collage, written and/or oral reports, debate, matching game, play, PowerPoint presentation... |
| **#3: Reading Science Fiction, Nonfiction or Empirical Data** | Comprehension & Application (Levels' 2 - 3) | * Utilizing diversified mediums of literature (textbook, novels, magazines, online sources, newspapers, reference materials...) and/or empirical data, students apply previously learned information in a new and concrete situation to solve problems. | articulate, teach, assess, chart, collect, record, experiment, manipulate, compute, construct, illustrate, discover, solve, operationalize ... | table, spreadsheet, chart, graph, scavenger hunt (WebQuest), collection, illustration, mobile, collage, pop-up book, solving math word problems, model, painting, sculpture, mural... |
| **#4: Retelling Comprehension** | Application (Level 3) | * The initial behavioral objective is to "restate" information learned in Lesson # 3 in a new and concrete situation. | apply, stimulate, change, demonstrate, create, show, compute, illustrate, record, experiment, translate... | diary, choral activities, choreographed dance, diorama, essay, graph, interview, personal reflection, poems, painting, student created Web site of relevant hyperlinks (ie: Filamentality)... |
| **#5: Research Project** | Application & Analysis (Levels' 3 - 4) | * Utilizing diversified mediums of information (databases, online resources, encyclopedias, primary and secondary sources), the behavioral objectives center on researching specific components of the inquiry unit that have aroused "student curiosity" and will aid students in developing divergent conclusions, making inferences and /or finding evidence to the generalization. | apply, classify, diagram, dissect, analyze, infer, compare and contrast, correlate, identify the motives/causes, locate evidence, support, summarize, draw conclusions... | report, debate, play, animated movie, mural, collection, photo display, mobile, demonstration, pamphlet, detailed illustration, PowerPoint presentation, student created Web site...<br>* The research project must include a "reference list" and some of the following student activities: graphic organizers (software, Venn Diagrams → student/teacher created), table, spreadsheet, pictorial, chart, outline, survey, questionnaire... |

| | | | | |
|---|---|---|---|---|
| **#6:<br>Retelling the Research** | Analysis<br>&<br>Synthesis<br>(Levels' 4 - 5) | * The initial behavioral objective is to "produce a new piece of knowledge" which is a combination of new information culled from the research project (lesson #5) and the student's previous knowledge as defined in lesson #1. | analyze, categorize, propose, predict, discover, produce, create, formulate, alter, modify, integrate, develop, reconstruct, invent, validate… | graphic organizers, model, blueprint, chart, experiment, innovative design, new invention, new solution, original and creative communications in the aesthetics (editorial essay, choral reading, song, chant, pop-up book, collage, mural, sculpture, illustration, interpretive dance, pantomimes, skits, role play…)…. |
| **#7:<br>Retelling the Research (Alternate Form of Assessment)** | Analysis<br>&<br>Synthesis<br>(Levels' 4 - 5) | * To repeat the initial behavioral objective(s) of lesson #6 with an <u>alternate form of assessment</u> → student product(s) will be geared towards a different multiple intelligence(s) from lesson #6.<br>* The goals is to "engage" as many learning styles as possible. | ↑<br>refer to above criteria | ↑<br>refer to above criteria |
| **#8:<br>Reflection on Learning** | Synthesis<br>&<br>Evaluation<br>(Levels' 5 -6) | * Utilizing the information learned in lesson #6 and #7, the initial behavioral objective is for students to apply their own "personal values and opinions" when judging the value of the new material elicited. | construct, solve, appraise, assess, critique, defend, interpret, scale, predict, editorialize, dispute, justify, evaluate, recommend, conclude, reframe… | creating original and creative communications in the aesthetics (advertisement, editorial essay, choral reading, song, chant, pop-up book, collage, new game/invention/design, timeline, mural, sculpture, illustration, interpretive dance, pantomime, skits, role play…)…. |
| **#9:<br>Taking Action: Going Beyond the Classroom to Share Inquiry Unit (Third Form of Assessment)** | Synthesis<br>&<br>Evaluation<br>(Levels' 5 -6) | * Utilizing information learned in lesson #'s 1-8, students will "share salient points" of their science inquiry unit with students outside their immediate classroom.<br>* This activity can take <u>various</u> forms and should be geared towards "several multiple intelligences" in order to engage a maximum amount of learners. | ↑<br>refer to above criteria | science fairs, creating a class play/mural/collage that embodies predictions and recommendations, designing a scavenger hunt/WebQuest, bulletin boards displayed in the school hallway, inter-grade sharing, sending letters to local politicians, sharing information via video-conferencing with local, national, and international classrooms, museums, and educational organizations…<br>* Advanced techno-savvy learners can create their own Web site on the global highway….. |

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**Appendix A**

Lesson #2[1]

**Plant Detectives**

**Bloom's Taxonomy:** Level 2 - Comprehension.
**Gardner's Multiple Intelligence(s):** Visual/Spatial, Naturalist.
**Children's Literature:** *How Plants Grow* by Angela Roylston.

**Math Skills:**

a. Process Standards: Reasoning and Proof; Connections; Mathematical Representation.
b. Content Standards: Numbers and Operations; Measurement; Data Analysis and Probability.

**Science Skills:**

a. Science Inquiry Skills: Observation, Classification, Communication, and Inference.
b. Manipulative Skills: Grouping objects.

**Behavioral Objectives:**

1. To understand the function of a leaf vein and the three classifications of leaves according to properties of "vein patterns."
2. To classify into three distinct groups of leaves (pinnate, palmate, and parallel) and create rubbings/etchings of found objects to "reinforce" like properties of "vein patterns."
3. To create a mathematical representation (bar, pie/circle, or picto-graph) of grouped findings using pragmatic software (ie: MS Excel or The Graph Club).

**MST Standard:**

Standard 2: Students will access, generate, process and transfer information using appropriate technologies.

**Benchmark:**

a. Use a variety of equipment and software packages to communicate information.

**ELA Standard:**

Standard 3: Students will read, write, listen, and speak for critical analysis.

**Benchmark:**

a. Recognize that the criteria that one uses to analyze and evaluate anything depends on ones point of view and purpose for the analysis

(1) Portions of this lesson are from the MST Science Inquiry Unit on "Plant Life" created by Francine Martyn and Linda Quinn-Henderson at S.U.N.Y. College at Old Westbury, 2002.

**The Arts Standard:**
Standard 1: Students will actively engage in the processes that constitute creation and performance in the arts (visual arts) and participate in various roles in the arts.

**Benchmark:**

a. Experiment and create art works, in a variety of mediums (drawing, printmaking, and computer graphics), based on a range of individual and collective experiences.

**Motivational/Constructivist Activity:**
Bring in diversified "local" examples of plant and tree leaves for students to analyze and ask "*Where can they be found*?" and "*Why do they look so different*?"

**Procedures:**

1. Read to the class "*How Plants Grow*" by Angela Roylston.
2. Refer to text while asking the following:
    a. "What *is the main function of a leaf vein*?" Closed-ended question.
        i. Answer: To transport the life-sustaining materials (water, minerals, and sugar created by the leaf) throughout the plant.
    b. "*Do we group leaves according to "vein type*?" Closed ended question.
        i. Answer: Yes, there are three types of vein patterns (pinnate, palmate, or parallel) and they are classified according to like properties/patterns.
3. Prepare students for a nature walk around the outside the school building.
4. Supply bags for collecting gathered objects and flat square crayons and paper for leaf rubbings/etchings.
5. Inform the students they will be acting as "*Plant Detectives*" and will gather various types of leaves for each category based upon vein pattern.
6. Upon returning ask students the following open-ended questions:
    a. "*What was your favorite find from the nature walk*?"
    b. "*Were you surprised at your findings*?
7. Upon completion of class discussion, students will create a collage by pasting diversified leaves into three distinct groups/categories according to vein patterns.
8. To reinforce knowledge of "vein properties," students will create rubbings/etchings from their collage and define (label) and quantify each category.
9. In cooperative groups, students will use software to create a mathematical representation of their findings in either a bar, pie/circle, or picto-graph.
10. Each group will discuss their findings.

**Materials:**

1. Computer.
2. Applicable graphing software: ie MS Excel or Tom Snyder's Graph Club.
3. Bags for collecting nature walk objects.
4. Glue for pasting leaves and large flat crayons and lightweight paper for rubbings/etchings.

**Assessment:** *Corresponding to Behavioral Objectives and Assessments* (See Rubrics)

**A.** To group leaves into three distinct categories based upon "like properties/patterns" of leaf veins. (Behavioral Objectives' #1 and #2)

**B.** To create a mathematical representation (bar, pie/circle, or picto-graph) of grouped findings using computer software. (Behavioral Objective #3)

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**Rubrics:** *Corresponding to Behavioral Objectives and Assessments*

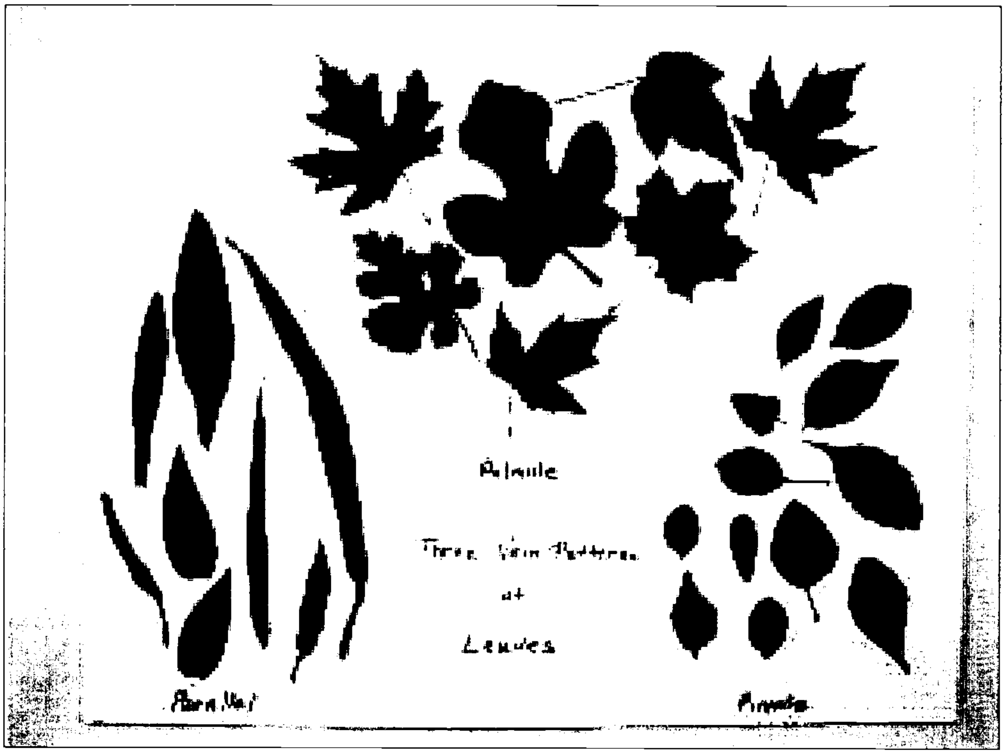
**Rubric A: Nature Walk Rubric**

(Also refer to Sample Student Collage and Sample Student Rubbings/Etchings)

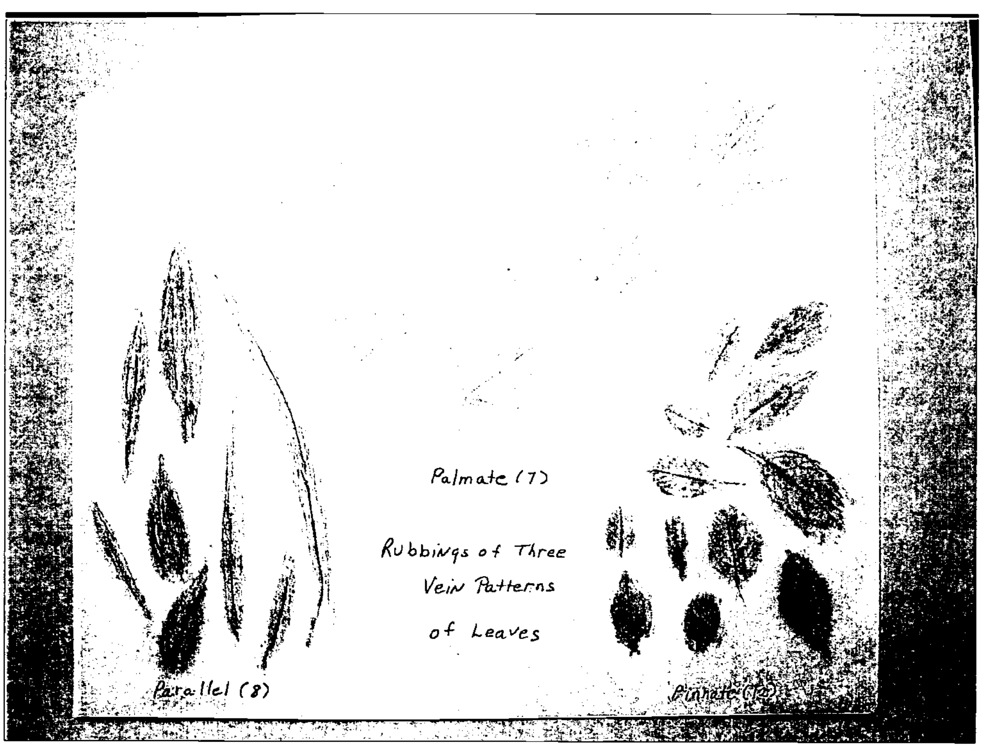
| **Criteria** | **Excellent (4)** | **Satisfactory (3)** | ***Limited (2)** | ***Poor (1)** |
|---|---|---|---|---|
| Identification of leaf groups from nature walk | All vein patterns identified (100%) correctly. | Most vein patterns identified (75%) correctly. | Some vein patterns identified (50%) correctly. | Unable to identify vein patterns (≤25%) correctly. |
| Classification of three leaf groups according to vein patterns. | All vein patterns grouped (100%) correctly | Most vein patterns grouped (75%) correctly. | Some vein patterns grouped (50%) correctly. | Unable to group vein patterns (≤25%) correctly. |
| Mathematical representation of "Three Vein Patterns" using graphing software | Correct application (100%) of graphing software. No Errors | Good understanding of graphing software. One minor error: (Omits the title or axes label(s) or object label) | Limited understanding of graphing software. Two minor errors or 1 major error (miscalculation or unequal frequencies) | Beginning knowledge of graphing software. Two or more major errors. |

*** Remediation Needed (lesson must be reintroduced)**

**Sample Student Collage**



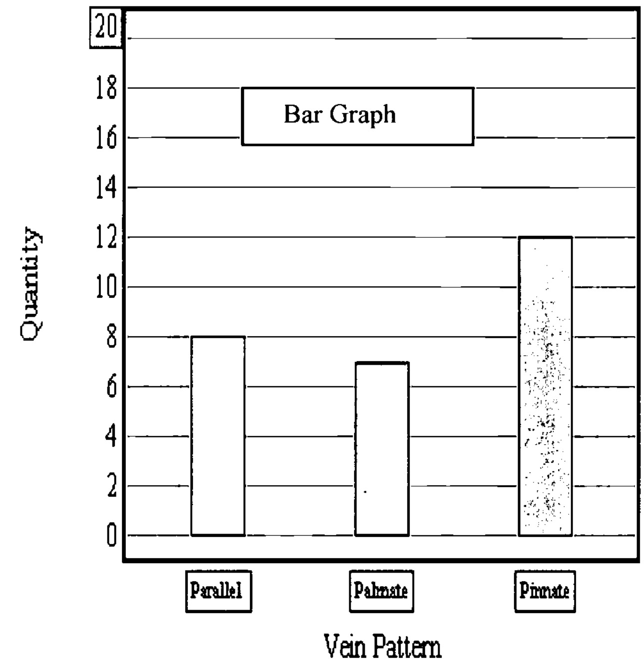
**Sample Student Rubbings/Etchings from Collage**

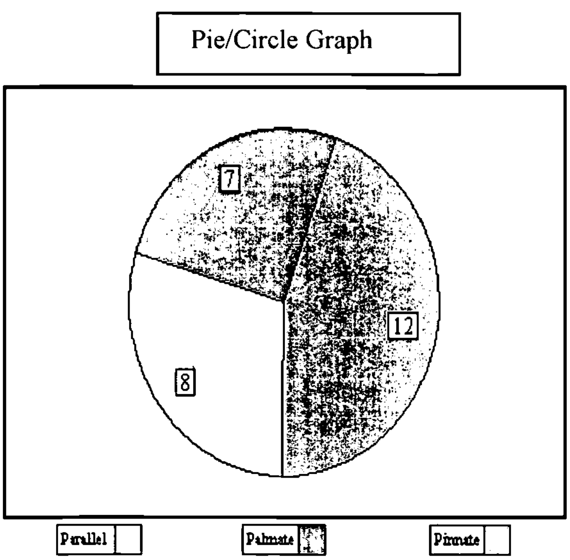


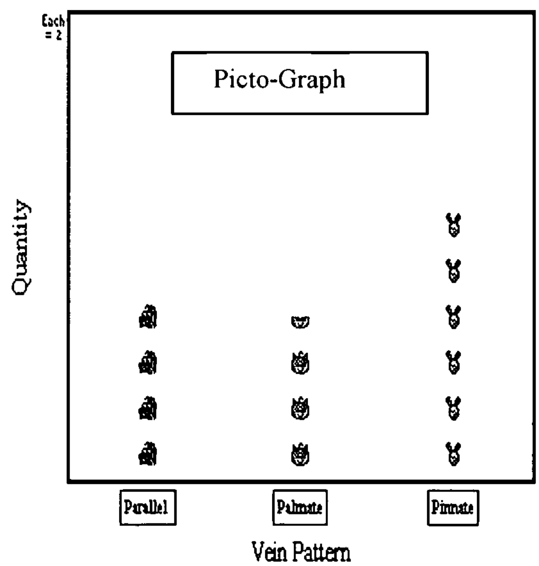
**Rubric B: Mathematical Representation**
**Title of Graphs: Three Vein Patterns of Leaves**

*(All tables and graphs created with the software "The Graph Club:" Tom Snyder Productions, 2002).*

| Three Vein Patterns of Leaves | |
|---|---|
| Vein Pattern | Quantity |
| Parallel | 8 |
| Palmate | 7 |
| Pinnate | 12 |

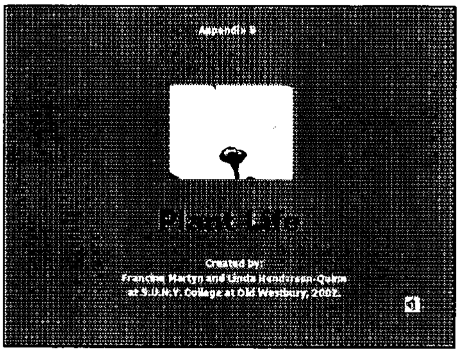


## Appendix B: PowerPoint Slides of "PLANT LIFE" MST Inquiry Unit [2] in .jpeg Format

Slide 1

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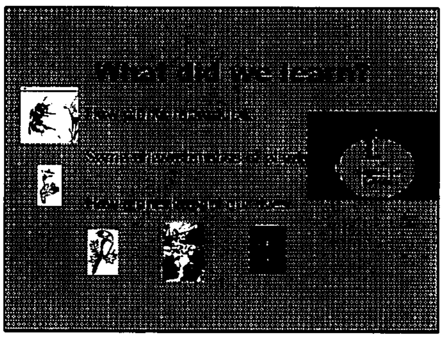


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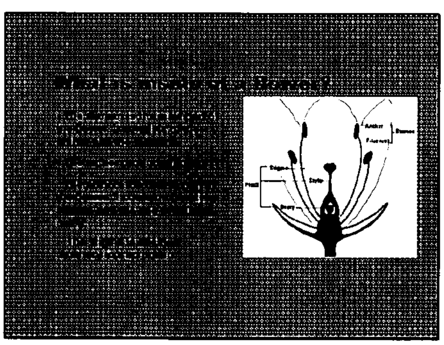

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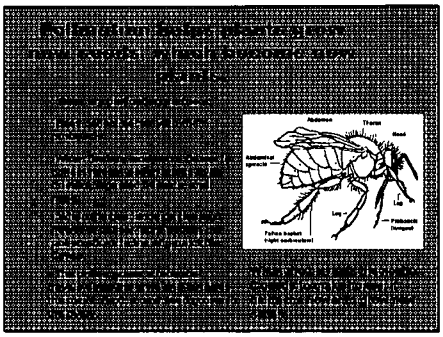

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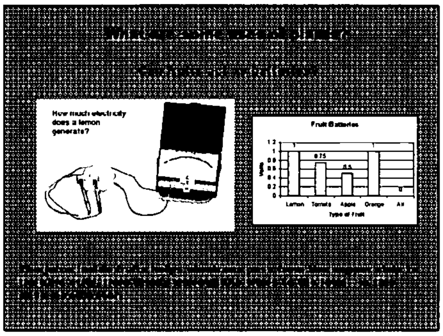

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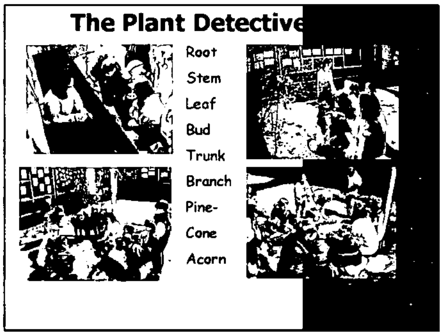


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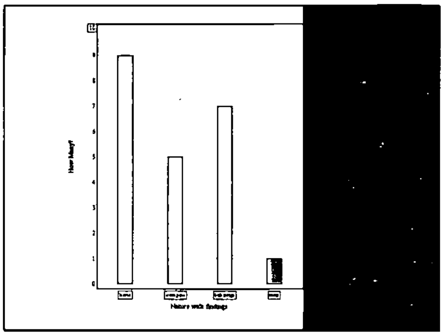

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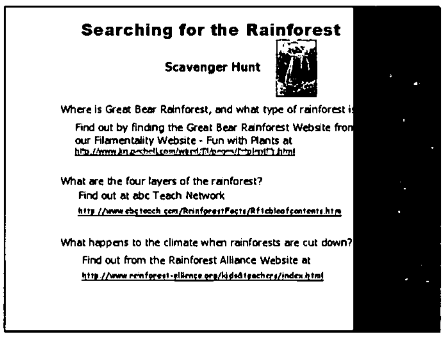
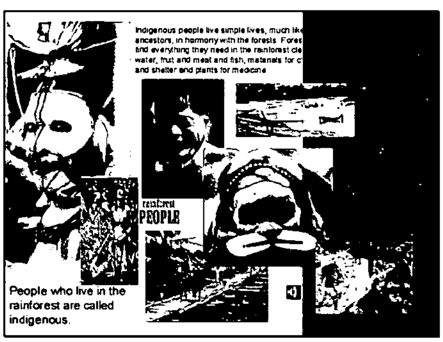



Slide 9

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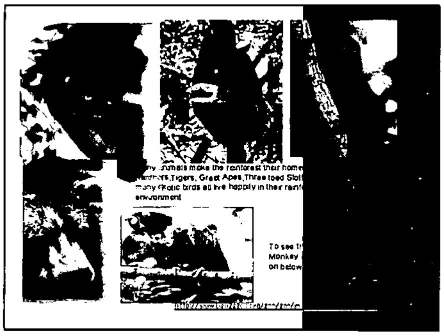
Slide 10

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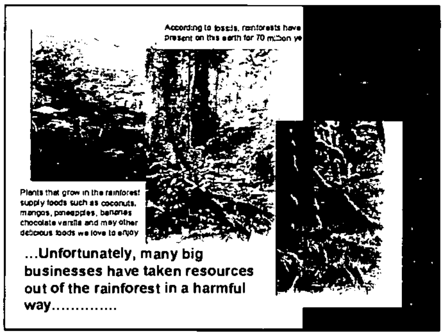


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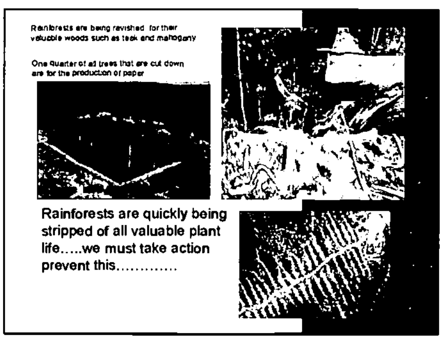


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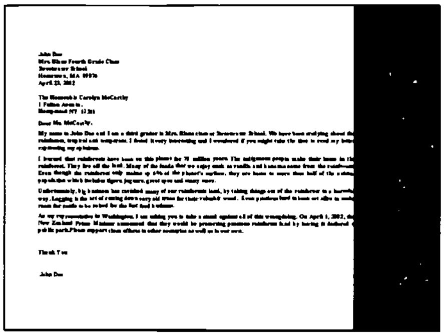
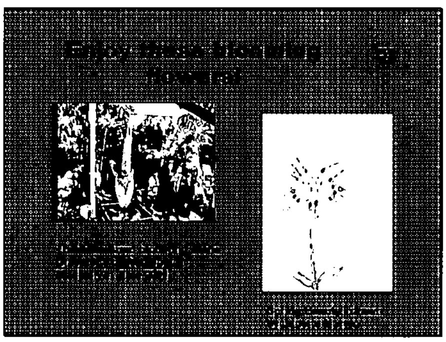
Slide 13



Slide 14



(2) "Plant Life.ppt" created by Francine Martyn and Linda Quinn-Henderson at S.U.N.Y. College at Old Westbury, 2002. This PowerPoint is also online at http: triton.oldwestbury.edu/~oconnors inquiryunitplantlife.htm

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