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Technologies for Inquiry-Based Learning

Presented by: Dr. Edwin Christmann

May 24, 2011

Technology-Based Inquiry

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Presented to the NSTA

Most of the material from this presentation
can be found in:

Christmann, E.P. (2006). Technology-Based Inquiry for Middle school. National Science Teachers Association Press: Arlington, VA.

Introduction

- The *National Science Education Standards* (NSES p. 23) defines scientific inquiry as "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Scientific inquiry also refers to the activities through which students develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world." The Science as Inquiry Standard in NSES includes the abilities necessary to do scientific inquiry and understanding about scientific inquiry.

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Introduction

- Scientific inquiry reflects how scientists come to understand the natural world, and it is at the heart of how students learn.
- From a very early age, children interact with their environment, ask questions, and seek ways to answer those questions.
- Understanding science content is significantly enhanced when ideas are anchored to inquiry experiences.

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What is Science?

- Trefil and Hazen (2004) explain that, based on experiments and observation, science is a way of knowing that answers questions about the natural world that surrounds us. Subsequently, science is based on verifiable facts about physical phenomena. According to the tenets of the National Science Standards (1996), students should be guided by the following principles when studying science:
- Science is for all students.
- Learning science is an active process.
- School science reflects the intellectual and cultural traditions that characterize the practice of contemporary science.
- Improving science education is part of systematic education reform.

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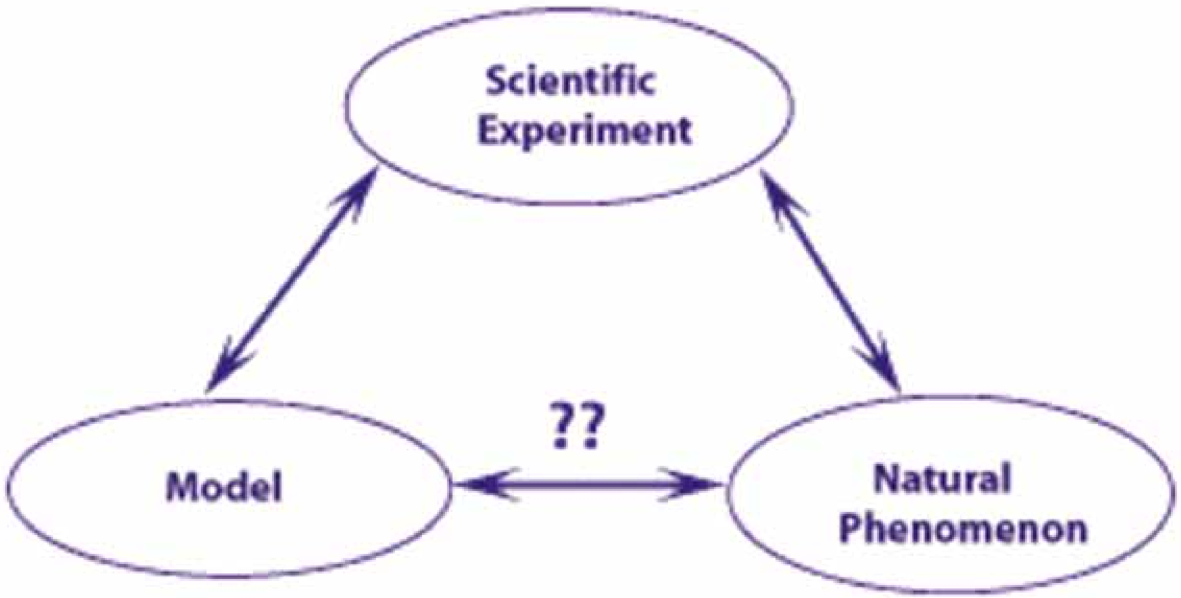
Key Components of Scientific Inquiry



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Simplist Form of Scientific Inquiry

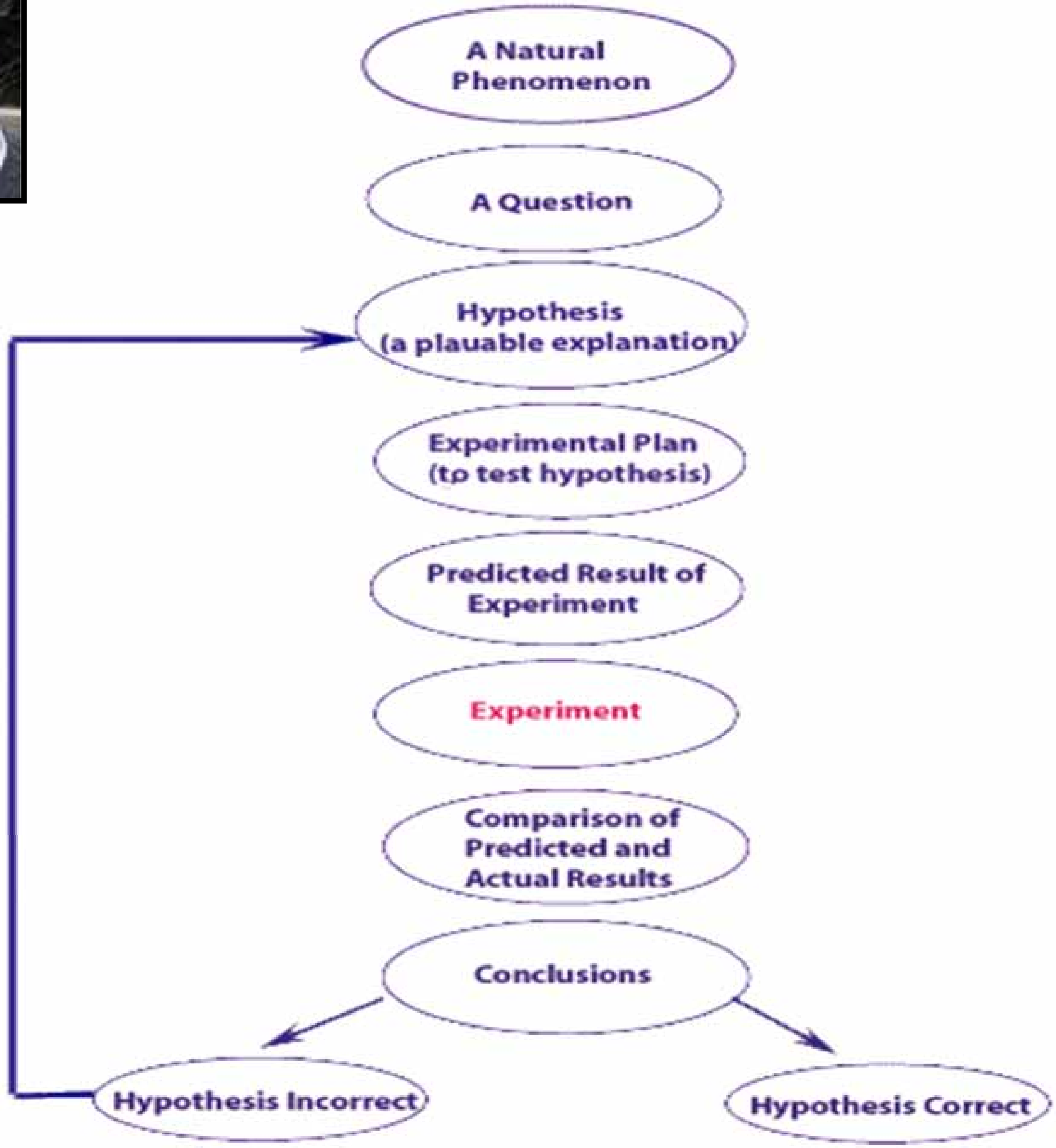

TABLE 6.1. SCIENCE AS INQUIRY STANDARDS

LEVELS K-4	LEVELS 5-8	LEVELS 9-12
Abilities necessary to do scientific inquiry	Abilities necessary to do scientific inquiry	Abilities necessary to do scientific inquiry
Understanding about scientific inquiry	Understanding about scientific inquiry	Understanding about scientific inquiry

TABLE 6.5. SCIENCE AND TECHNOLOGY STANDARDS

LEVELS K-4	LEVELS 5-8	LEVELS 9-12
Abilities to distinguish between natural objects and objects made by humans	Abilities of technological design	Abilities of technological design
Abilities of technological design	Understanding about science and technology	Understanding about science and technology
Understanding about science and technology		

Scientific Inquiry

- Scientific inquiry is a powerful way of understanding science content. Students learn how to ask questions and use evidence to answer them.
- In the process of learning the strategies of scientific inquiry, students learn to conduct an investigation and collect evidence from a variety of sources, develop an explanation from the data, and communicate and defend their conclusions.

Scientific Inquiry

- The National Science Teachers Association (NSTA) recommends that all K-16 teachers embrace scientific inquiry and is committed to helping educators make it the centerpiece of the science classroom.
- The use of scientific inquiry will help ensure that students develop a deep understanding of science and scientific inquiry.

NSTA Recommends

- Regarding the use of scientific inquiry as a teaching approach, NSTA recommends that science teachers:
  - Plan an inquiry-based science program for their students by developing both short- and long-term goals that incorporate appropriate content knowledge.
  - Implement approaches to teaching science that cause students to question and explore and to use those experiences to raise and answer questions about the natural world. The learning cycle approach is one of many effective strategies for bringing explorations and questioning into the classroom.

NSTA Recommends

- Guide and facilitate learning using inquiry by selecting teaching strategies that nurture and assess student's developing understandings and abilities.
- Design and manage learning environments that provide students with the time, space, and resources needed for learning science through inquiry.
- Receive adequate administrative support for the pursuit of science as inquiry in the classroom. Support can take the form of professional development on how to teach scientific inquiry, content, and the nature of science; the allocation of time to do scientific inquiry effectively; and the availability of necessary materials and equipment.

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NSTA Recommends

- Experience science as inquiry as a part of their teacher preparation program.
- Preparation should include learning how to develop questioning strategies, writing lesson plans that promote abilities and understanding of scientific inquiry, and analyzing instructional materials to determine whether they promote scientific inquiry.

Regarding students' abilities to do scientific inquiry, NSTA recommends that teachers help students:

- Learn how to identify and ask appropriate questions that can be answered through scientific investigations.
- Design and conduct investigations to collect the evidence needed to answer a variety of questions.
- Use appropriate equipment and tools to interpret and analyze data.
- Learn how to draw conclusions and think critically and logically to create explanations based on their evidence.
- Communicate and defend their results to their peers and others.

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Regarding students' understanding about scientific inquiry, NSTA

recommends that teachers help students understand:

- That science involves asking questions about the world and then developing scientific investigations to answer their questions.
- That there is no fixed sequence of steps that all scientific investigations follow. Different kinds of questions suggest different kinds of scientific investigations.
- That scientific inquiry is central to the learning of science and reflects how science is done.
- The importance of gathering empirical data using appropriate tools and instruments.
- That the evidence they collect can change their perceptions about the world and increase their scientific knowledge.
- The importance17 of being skeptical when they assess their own work and the work of others.
- That the scientific community, in the end, seeks explanations that are empirically based and logically consistent.

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Let's pause for questions from the audience

Some Examples of Activities and Technologies for Technology-Based Inquiry

- Where does a teacher start?
- Resources?
- Funding?

Time?

- I always begin my class with a discussion of time?
  - Question "What is time?"
    - Time duration
    - Time Standard
    - Classroom Extensions
    - Time measurement as a technology
    - How do we measure time?
    - Reliability and validity?

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Longitude

- After the construct of time is introduced, an introduction to A& E's video and Dava Sobel's book "Longitude" shows the process of scientific inquiry, technology, and shows how the measurement of time led to cultural progress.
  - Sobel, D. (1996). Longitude: The True Story of a Lone Genius Who Solved the Greatest Scientific Problem of His Time. Penguin Publishing, New York.

Who Solved the Longitude problem?

- John Harrison
  - – Longitude prize (1714)
    - Newton
    - Halley

The Solution (50 Years later…)

GPS


etrex
LEGEND
Panning...
Ready To Navigate
Accuracy: 16 Feet
12000 Mission Rd
GARMIN

GPS

- When you turn on your inexpensive and quite portable GPS device (available in watch form), it receives data at the speed of light from at least six of the GPS satellites in orbit.
- An internal clock on the satellite, that is accurate to within three nanoseconds, measures the time it takes for a signal to travel from the device to the satellite.
- Then the distance between the device and satellite is calculated by multiplying the time by the speed of light.
- It is then possible to determine the precise latitude, longitude, and altitude of the device by processing data from four separate satellites.

GPS Activity

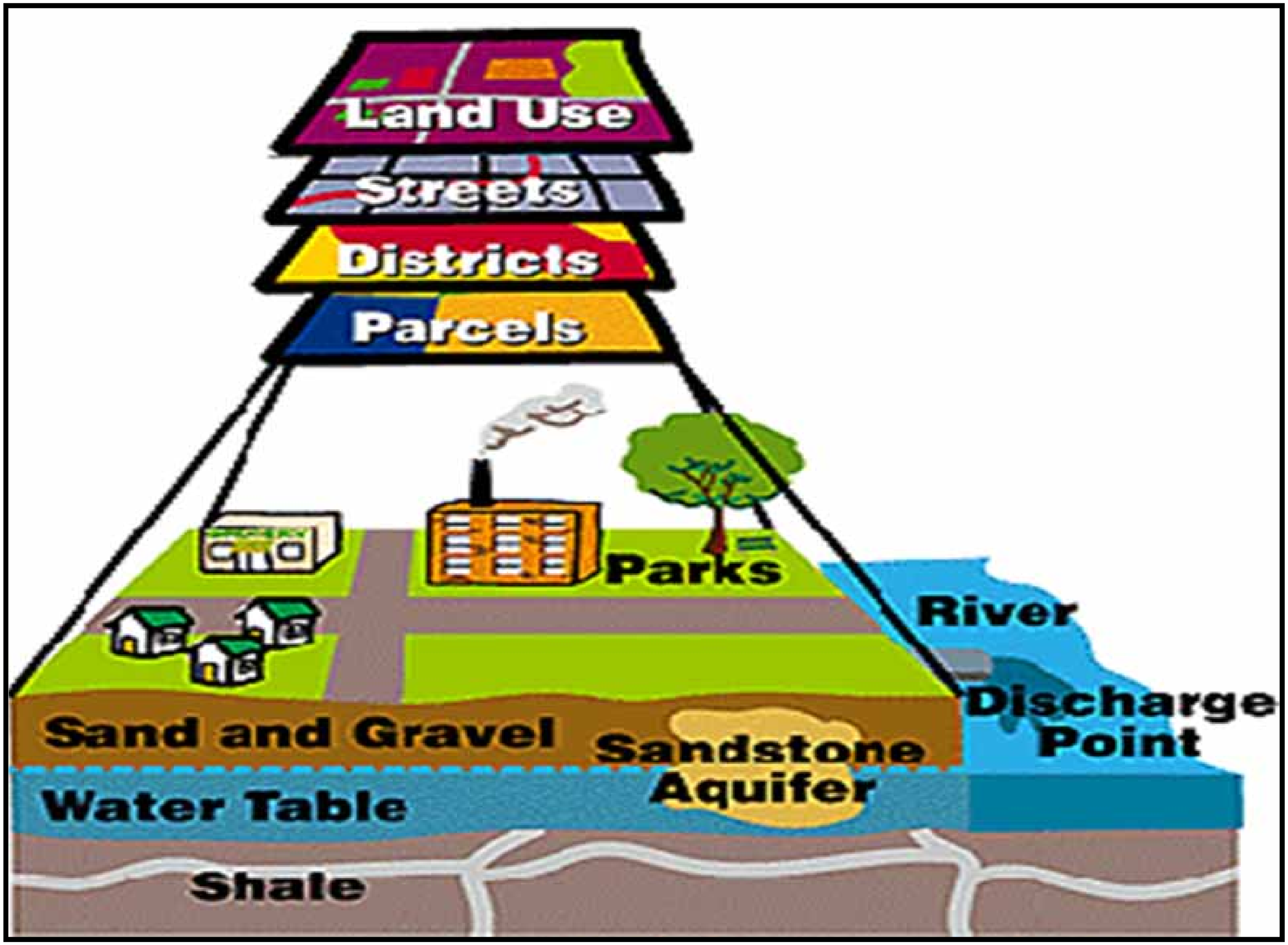
- Before you actually put a GPS unit in students' hands, you will need to review the concepts of latitude and longitude. Specifically, students will need to know that measurements are taken in degrees, minutes, and seconds, and that one minute of latitude equals 1 nautical mile. (See September 2002 Tech Trek for more information on longitude). One way of reinforcing the concepts is to display a nautical chart in the room and ask students to provide the longitude and latitude of several points at sea and along the coast. You can also ask them to develop a route from Point A to Point B using several waypoints, and have them mark the latitude and longitude of each. Because navigation requires maintaining compass headings, ask them to determine the degree of angle for each of the turns they will be making at each waypoint along the route, and have them calculate the reciprocal angles of turn for the trip home.

How many GPS satellites are located in orbits 11,000 nautical miles above the Earth?

A) 32
B) 28
C) 24
D) 12

GIS

- **What is GIS?**
- Simply put, a GIS combines layers of information about a place to give you a better understanding of that place. What layers of information you combine depends on your purpose—finding the best location for a new store, analyzing environmental damage, viewing similar crimes in a city to detect a pattern, and so on.



Land Use
Streets
Districts
Parcels
Parks
River
Discharge Point
Sand and Gravel
Sandstone Aquifer
Water Table
Shale

GIS – In the Classroom

- **GIS and Assessment**
- Not only can GIS facilitate performance-based assessments that stress the collection, organization, integration of information; GIS illustrations can be used to measure complex academic achievement through the use of the interpretive exercise question. For example, with GIS illustrations, an interpretative exercise question can be designed as a series of multiple-choice questions where students give responses at Bloom's analysis level. Therefore, middle school science teachers will have a greater range of flexibility in measuring the higher levels of learning (e.g. ability to recognize inferences, assumptions, & relevance of information).

GIS Resources

- U.S. Geological Survey
- http://www.usgs.gov/research/gis/title.html
- ESRI's Schools and Libraries Program
- http://www.esri.com/industries/k-12/basicgis.html
- Association for Geographic Information (AGI).
- http://www.geo.ed.ac.uk/agidict/welcome.html
- Volusia County, Florida
- http://volusia.org/gis/whatsgis.htm
- GIS Jump Station
- http://www.gis.com/jumpstation/
- GIS.com
- http://www.gis.com/
- Kansas
- http://kangis.org/
- Illinois
- http://www.gisillinois.org/index.html
- Massachusetts
- http://www.state.ma.us/mgis/gisedu.htm

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PDAs

Figure 1. Periodic Table for Palm OS® v.2.33

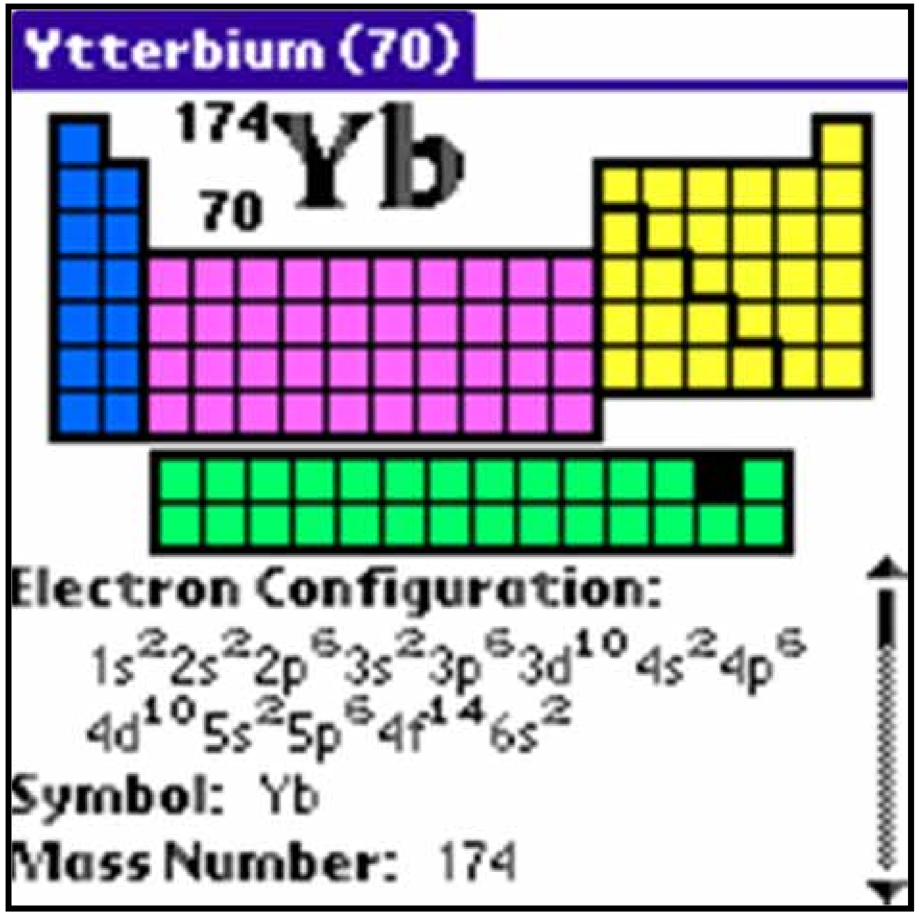

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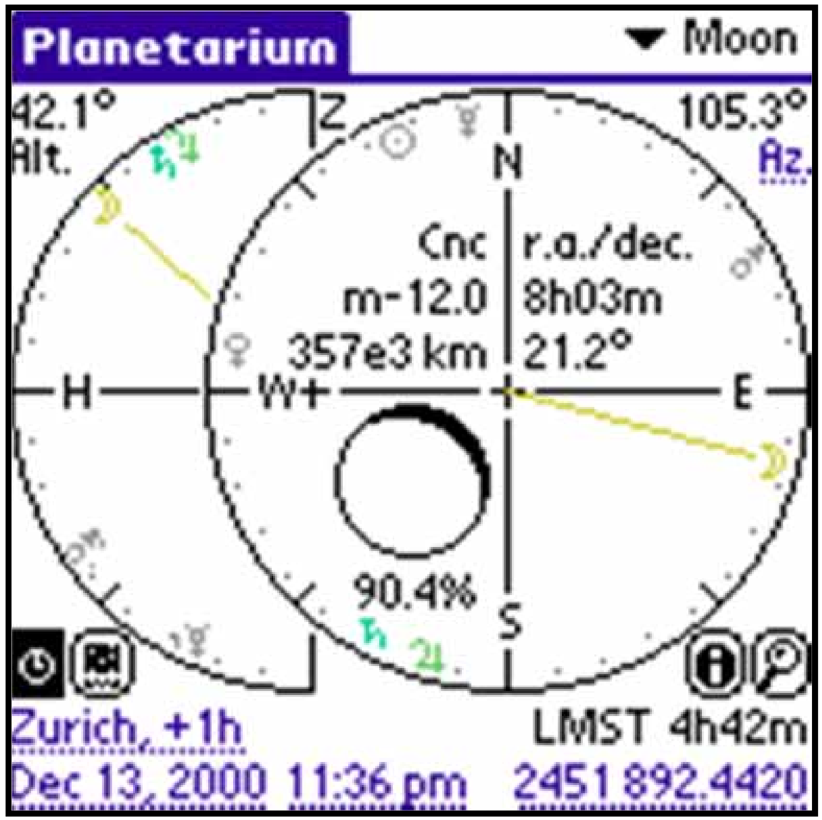
Figure 2. Planetarium v.2.1.1



References

- American Association for the Advancement of Science (1993). *Benchmarks for science literacy*. New York: Oxford University Press.
- National Research Council (1996). *National science education standards*. Washington, DC: National Academy Press.
- National Research Council (2000). *Inquiry and the national science education standards: A guide for teaching and learning*. Washington, DC: National Academy Press.

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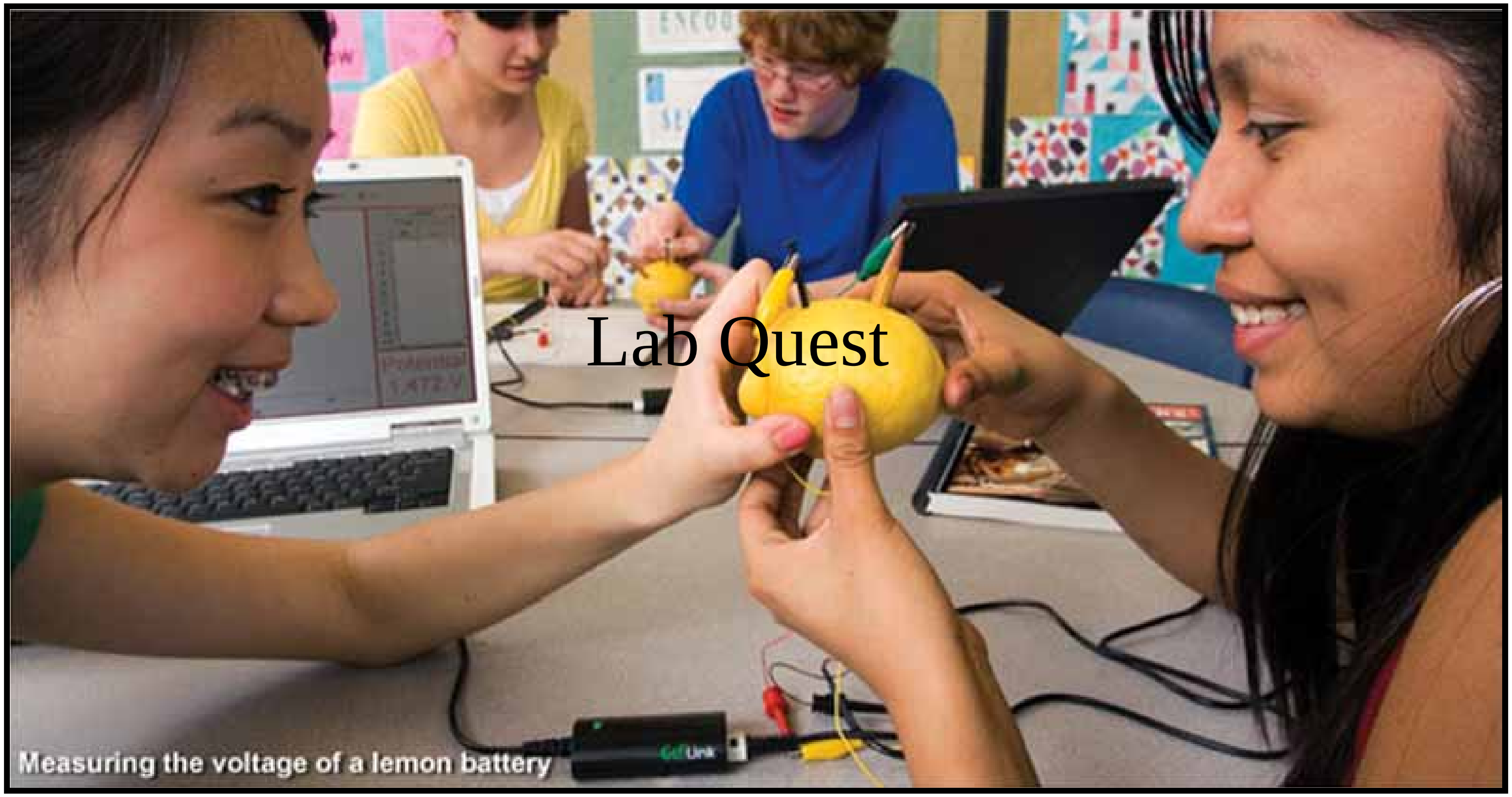
PDA Temperature Probe & HACCP Recording System



Lab Quest

Measuring the voltage of a lemon battery

Let’s pause for questions from the audience

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Celestial Observation

- **http://skyandtelescope.com/observing/skychart/#**

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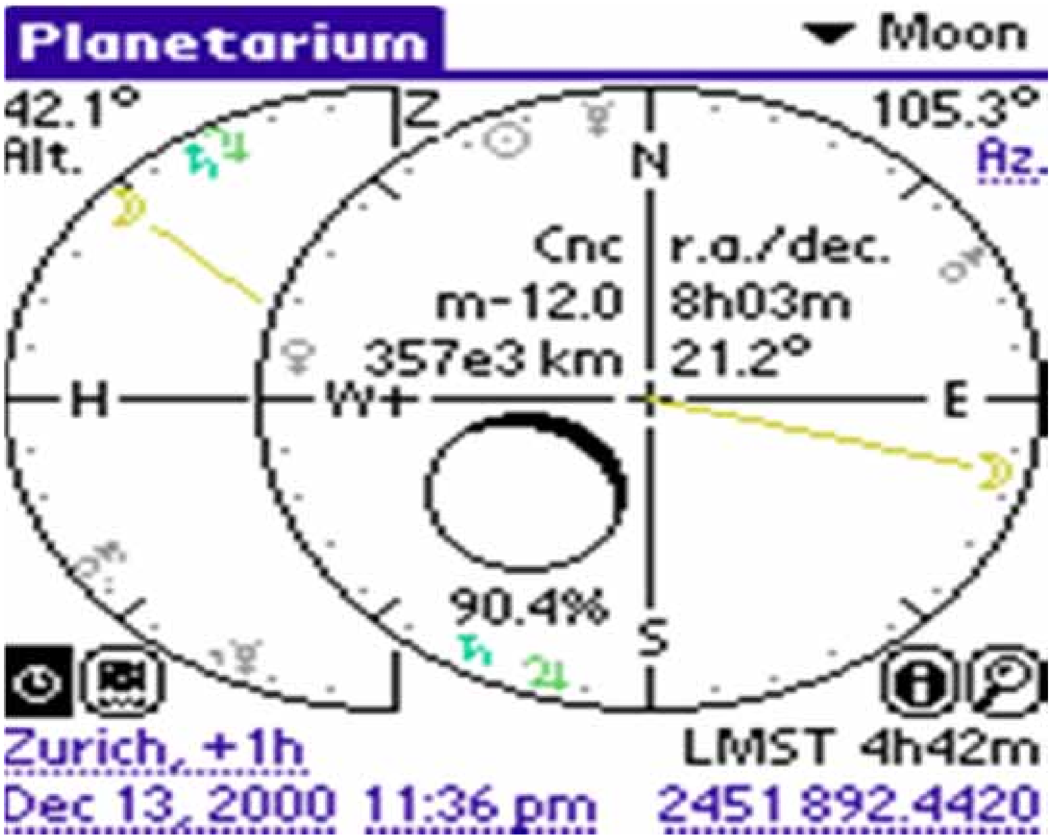
N
Ursa Major
Ursa Minor
Draco
Lynx
Camelopardalis
Cepheus
Lyra
Cygnus
Gemini
Auriga
Cassiopeia
Lacerta
Perseus
Vulpecula
Sagitta
E
Andromeda
Triangulum
Delphinus
Aquila
W
Orion
Taurus
Aries
Pegasus
Equuleus
Pisces
Cetus
Aquarius
Capricornus
Lepus
Eridanus
Fornax
Piscis Austrinus
Sculptor
Phoenix
S

Personal Digital Assistant (PDA)

If you have a Personal Digital Assistant, such as the Palm Pilot, stargazing software is available at a minimal expense for portable use (see Figure 5).

Figure 5. Planetarium Software for the PDA



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Sample Celestial Observation Activity

- <u>Making Observations</u>. Once you have found Jupiter, you need to plan on observing the planet everyday for 2 1/2 weeks. Because it takes about 17 days to complete this experiment. You will need to assume that there will be evenings when the weather does not cooperate and Jupiter is not visible (I'm sure Galileo had the same problem). If you need to miss a day of observation, note the missed observation and resume the next day if possible.
- Activity Steps:
- Over a period of 17 days, observe Jupiter with a telescope at different time periods.
- Having all students involved in the daily observations is highly recommended. However, having students work in pairs with each group responsible for one night of observation is acceptable based on time constraints. In addition, the teacher needs to check the daily observations for accuracy.
- Have students draw a sketch similar to Figure 3 for each observation session, which depicts the positions of the moons in relation to Jupiter.
- After all of the observations are made, have the students answer the following questions on a sheet of paper, (note: make sure that all 17 sketches are attached).
- Questions:
  - How many satellites (moons) are visible? (4)
  - Compare the sketches and identify the satellites on the sketches by labeling the sketches with the names of the moons.
  - How many days does it take each satellite to complete an orbit around Jupiter (see table 1)?
- Note: Students will be able to identify Galilean moons by comparing the rates at which their positions change and the actual distance each moon appears from Jupiter (see Table 1). In the case of IO, for example, Io is a large, rocky, volcanically active moon of Jupiter. Its volcanoes spew out molten sulfur, making Io a very colorful moon. It is the innermost of Jupiter's four large moons and the third largest. It has a diameter of 1,942 miles (3,636 km), very close in size to our moon. Io's mean distance from Jupiter is 220,000 miles (422,000 km). It has a mass of 8.93×10^{22} kg. It takes Io 1.77 days to orbit Jupiter.

National Standards – NCTM Conversions

- **“In the United States, given that the customary English system of measurement is still prevalent, students from elementary grades through high school learn both customary and metric systems. Students should understand both systems, make conversions easily within systems, and estimate measurements fluently in both. As an example, a student might say, ‘I live a mile from the school. That is about two kilometers.’ Students will find it helpful to know a few English-metric equivalents.”**

National Standards – NRC Conversions

- Likewise, as proposed in the NRC’s National Science Standards (1996), middle school students should be able to “observe and measure characteristic properties, such as boiling and melting points, solubility, and simple chemical changes of pure substances.”

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Conversions-Online Technologies

Table 1. Conversion Web Sites

- **Convert It**
- Http://www.image-ination.com/test_maker/convert.html
- **Digital Generation**
- Http://www.webcom.com/legacysy/convert2/convert2.html
- **Entisoft Units**
- Http://www.entisoft.com/esunits2.htm
- **International French Property Metric Conversion Tables**
- Http://www.french-property.com/
- **MegaConverter**
- Http://www.megaconverter.com/
- **Science Made Simple**
- Http://www.sciencemadesimple.com/
- **University of Berlin Conversion of Units**
- Http://www.chemie.fu-berlin.de/chemistry/general/units_en.html

Who was the U.S. president who petitioned Congress to adopt a system of dimensions and units based on multiples of 10?

A) Thomas Jefferson

B) Abraham Lincoln

C) Gerald Ford

D) Jimmy Carter

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Let’s pause for questions from the audience

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TI-73

- **Obviously, the possibilities for Web-based conversion sites and the TI-73 calculator are virtually endless for science teachers. Hopefully, the ideas presented here will generate additional professional discussion concerning technology-based classroom conversion applications for middle school science teachers, as well as to better prepare students for the national and global competition of the twenty-first century.**

All of the following can be accomplished with a TI-83 Calculator EXCEPT:

A. Multimedia.
B. Graphing.
C. Programming.
D. Statistical analysis.


LENGTH cm▸
1:mm
2:cm
3:m
4:inch
5:ft
6:yard
7↓km

Using Graphing Calculators for Statistics

- Using either the TI-73 or TI-83 graphing calculator, you can easily calculate the mean and standard deviation by following these keystrokes.

Calculator Exploration

TI-73

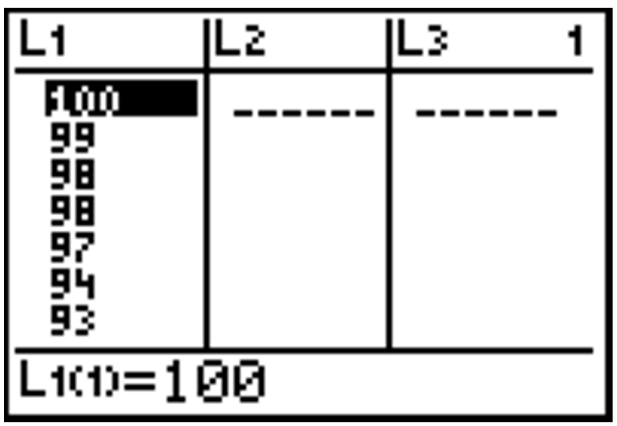
Step 1) Display list editor by pressing [**LIST]**.

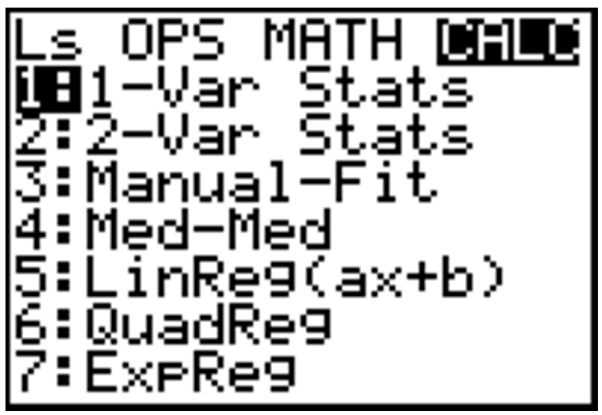
Under L1 enter all 25 scores from class A in Table 11.1.

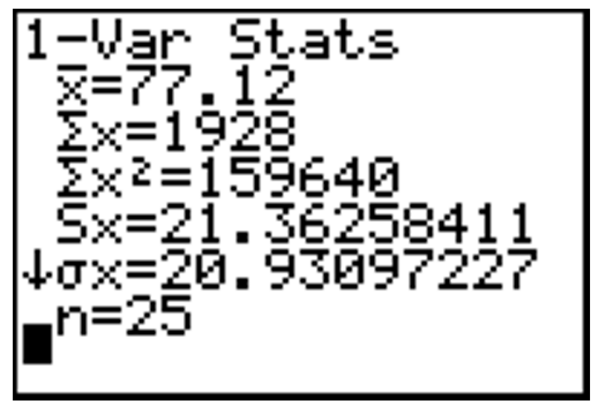
Step 2) Press **2nd** [**LIST]** to activate STAT.

Next, scroll to the right and select **CALC.**

Next, scroll down to **1: 1 – Var Stats**, press [**1],** then press **ENTER**







Over the past 25 years, personal use of the Internet has:

stabilized	
decreased	
increased	
remained constant	

Research on the Internet in Sciences

- Obviously, the potential for Internet-based research is endless. Additional professional discussion concerning Internet research applications for middle school science teachers is encouraged, and the focus of that conversation must be the preparation of students for the national and global dynamics of the twenty-first century.

Technologies for Special Needs Students

- Clearly the technology applications for special education instruction are limitless. As most of you will agree, it is important for special education students to feel comfortable and to be successful in school. For students with special needs, technologies can help make comfort and success possible.

Figure 1. Edmark's Virtual Electronics Lab

Recent Technology-Based Inquiry Articles

- Lucking, R.A., Al-Hazza, T.C. & Christmann, E.P. (2011). The move to movies: Instruction that engages, Science Scope, 34(7), 76-78.
- Lucking, R.A., & Christmann, E.P. & Spruce, R. (2010). Converting sunlight into other forms of energy: Using photovoltaic cells made from silicon alloys for solar power, Science Scope, 34(4), 52-55.
- Lucking, R.A., & Christmann, E.P. & Wighting, M.J. (2010). Hang up and learn: Cell phones in the science classroom, Science Scope, 33(9), 82-85.
- Lucking, R.A., & Christmann, E.P. & Wighting, M.J. (2010). Cell phones for science, Science Scope, 33(5), 58-61.
- Lucking, R.A., & Christmann, E.P. & Wighting, M.J. (2009). Podcasts and blogs, Science Scope, 33(3), 64-67.

Recent Technology-Based Inquiry Articles

Christmann, E.P. (2009). The Effects of Statistical Analysis Software and Calculators on Statistics Achievement. Policy Futures in Education, 7(4), 445-449.

Lucking, R.A., Wighting, M.J., & Christmann, E.P. (2009). TeacherTube for science, Science Scope, 32(8), 62-64.

Christmann, E.P. (2008). No need to weather the storm to collect data. Science Scope, 32(4), 68-70.

Lucking, R.A., Christmann, E.P. & Wighting, M.J. (2008). Make your own mashup maps, Science Scope, 31(8), 58-61.

Recent Technology-Based Inquiry Articles

- Lucking, R.A. & Christmann, E.P. (2008). The collaborative power of wikis, Science Scope, 31(6), 58-59.
- Lucking, R.A., Wighting, M.J., & Christmann, E.P. (2007). Electronic bulletin boards and digital student groups, Science Scope, 31(1), 24-26.

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