EMSE: Mathematics and Science K-8

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Status of Mathematics and Science Education

<table>
<thead>
<tr>
<th>Operation</th>
<th>Percentile in Grade</th>
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<tbody>
<tr>
<td></td>
<td>8th</td>
</tr>
<tr>
<td>Whole number manipulation</td>
<td>99</td>
</tr>
<tr>
<td>Multiplication &amp; 2 step problem solving</td>
<td>70</td>
</tr>
<tr>
<td>Fractions, decimals, percent</td>
<td>12</td>
</tr>
<tr>
<td>Algebra, geometry, statistics</td>
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Mathematical Demands of Society

Require knowledge of

- Graphs
- Calculations, e.g. discounts, insurance benefits etc
- Computer Literacy

- Mathematics is often taught as a set of ‘rules’ (algorithms) for obtaining answers

- Science is often a transfer of facts from teacher to student
Relationship between Math and Science
Evidence for round earth?

Flat Earth
Eratosthenes

The size of the Earth was first measured in Egypt by the geographer and mathematician Eratosthenes about 235 BC.
Size of Earth

7.2-degree angle between the sun's rays and the vertical pillar. 7.2 degrees is $\frac{7.2}{360}$, or $\frac{1}{50}$ of a circle.

Aristotle: 384-322 B.C.
Aristotle’s View of the Universe

Aristotle categorized motions as either "natural" motions or "violent" motions:

Natural Motion: Any motion that an object does naturally - without being forced - was classified by Aristotle as a natural motion. Examples of natural motions include:• A book lying at rest on a table naturally remains at rest. • If you let go of a book it naturally falls toward the earth. • Smoke naturally rises. • The sun naturally rises in the east, crosses the sky, then sets in the west.

Violent Motion: Aristotle classified any motion that required a force as a "violent motion". (He did not mean violent in the modern sense...) Examples of violent motion include:• Pushing a book along a table. • Lifting a book.

Summary: Basically, Aristotle's view of motion is "it requires a force to make an object move in an unnatural" manner - or, more simply, "motion requires force".

The Universe of Aristotle and Ptolemy
Retrograde Motion

The usual motion of planets as they "wandered" on the celestial sphere was eastward against the background stars. This is called "Direct" Motion. However, it was observed that at times the planets moved westward for some period on the celestial sphere; this was termed "Retrograde Motion". The episodes of retrograde motion were difficult to explain.

The Answer: Epicycles
The Copernican Model: A Sun-Centered Solar System
Retrograde Motion in Copernican System

Born: 19 Feb 1473 in Torun, Poland
Died: 24 May 1543 in Frauenburg (now Frombork), Poland

Hypotheses, Laws and Principles

When a hypotheses has been tested over and over again and has not been contradicted, it becomes a law or principle.

If a scientist finds evidence that a law has been contradicted then it must be abandoned e.g. Ptolemaic and Aristotelian View of Universe.
Ptolemy and Copernicus

The ideas that came to be held by most medieval thinkers descended from Aristotle. Aristotle's wrote that the heavenly bodies were fundamentally different from earthly bodies, both in behavior and composition. In Aristotle's view, the heavens were perfect and unchangeable. The Alexandrian Greek scientist Ptolemy, following Aristotle, wrote that (naturally) the earth was at rest in the center of the universe, and the Sun, Moon, planets, and stars moved about the Earth in circular orbits.

(A solar system with the Earth at the center is called a geocentric solar system - "geo" = Earth, etc.

Scientifically, the big problem with Ptolemy's ideas were the orbits of the planets. Viewed from the Earth over the course of several months, planets have a strange motion - sometimes they move forward, sometimes they stop, and move backward (retrograde motion).

Copernicus (1473 - 1543)

The Polish cleric Copernicus suggested, in the late 16th century, that the Sun was actually the center of the solar system, and that the Earth was a planet that revolved about the sun, just like any other planet. (This is a heliocentric Universe)

The heliocentric solar system requires the Earth to rotate on its axis once per day which means that you, at this moment have a speed of about 1 000 mi/hr (= 25 000 mi/24 hr).
Galileo and falling Bodies

<table>
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<tr>
<th>Time</th>
<th>Total Distance</th>
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<tbody>
<tr>
<td>0</td>
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</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3</td>
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$D \alpha t^2$

How fast and how far?

$d=5t^2$
Ancient Views

- Early ‘atomists’ believed that matter had a smallest indivisible bit, an atom.
- Aristotle, the most famous of the early Greek philosophers, didn't agree with the idea of atoms. In the fourth century BC he taught that all matter is composed of different combinations of four elements earth, air, fire, and water. This view seemed reasonable, for in the world around us matter is seen in only four forms: solids (earth), gases (air), liquids (water), and the state of flames (fire). Aristotle's ideas lasted for more than 2000 years.

Modern Views

- To date(2001) we know of 118 distinct atoms, called the chemical elements. Only 88 elements are found naturally; the others are formed in laboratories with high-energy nuclear accelerators and reactors. These heaviest elements are too unstable (radioactive) to occur naturally inappreciable amounts.
Ernest Rutherford

- New Zealand-born British physicist Ernest Rutherford, who in 1909 oversaw the now-famous gold-foil experiment
Psychological Foundation: Piaget’s Theory

- Intellectual development proceeds via an interaction between an organism (mind) and its environment.
- Just as an organism which adapts to changes, the mind assimilates perceptual stimuli into existing patterns of response and thereby undergoes a change.
Piaget’s Stages

- Sensory Motor (0-2): Reflexive, self-centered: will not look for hidden objects (identity operator)

- Preoperations (2-7): Centration, nonconservation
  Focuses on only one aspect of a problem

Non-Conservation Examples
• Concrete Operations (7-11): Conservation, reversibility

• Formal Operations: (11+) Hypothetical thinking, can test all possibilities

Factors Contributing to Development

• Maturation (neurological growth)
• Experience (with environment so that assimilation and accommodation can take place)
• Social Interaction (interchange of ideas)
• Equilibration: involves cognitive conflict and self-regulation)
Implications for Education

- Our teaching should be less verbal and not abstract.
- Use of concrete materials (manipulatives such as base ten blocks, fraction pieces)
- Children should interact with peers
- Open-ended activities

What and When

- Grades k-1: Prenumber concepts, whole numbers
- Grades 2-4: Whole number manipulations, fractions
- Grades 5-6: Fractions and Decimals
- Grades 7-8: geometry, introductory algebra, statistics, probability