

From Theory to Practice:

Placing history of science in the classroom

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The aims of science teaching :

- 1. To liberate teachers from the tyranny of textbooks.**
- 2. To humanize the teaching of science by placing it in rich contexts, informed by the history of science.**

Research in science education shows that students leave school with:

A knowledge of isolated, disconnected facts, based on memorization.

A problem solving ability, mostly based memorizing algorithmic procedures.

A poor understanding of the nature of science and a spotty knowledge of the history of science.

Arguments for introducing science by means of the history of science

1. History promotes a better understanding of scientific concepts and methods.
2. History connects the development of individual thinking with the development of scientific ideas.
3. Important episodes in the history of science and culture should be familiar to all students, because
....these episodes represent the cultural heritage of everyone.

...introducing science by means of the history of science...

4. History of science is necessary to understand the nature of science.
5. History counteracts the scientism and dogmatism that are often found in the media and even in texts and classrooms.
6. History humanizes the subject matter of science.

...introducing science
by means of the history of science...

- 7. History allows connections to be made within topics and disciplines of science as well as the humanities.**
- 8. There is, to some extent, a parallel between historical development and students' conceptual development.
*This parallel can often be recognized and should be used.***

UNITS OF HISTORICAL PRESENTATION (UHP)

- *Vignettes*
- *Case Studies*
- *Confrontations*
- *Thematic narratives*
- *Dialogues*
- *Science Drama*

UNITS OF HISTORICAL PRESENTATION...

1. A *Vignette* is the smallest unit of historical presentation.
2. *Case studies* are large-scale historical contexts that are generally much more complex and have more diverse connections than *vignettes*.
3. *Confrontations* concern competing theories seeking to lay the foundations of a new discipline.

UNITS OF HISTORICAL PRESENTATION...

4. *Thematic narratives* identify general themes that transcend the boundaries of individual scientific disciplines.

5. *Dialogues* can be written in which the original scientists are made to speak of their ideas and theories.

6. *Science Dramas* deal with the role of the scientist in society.

Examples of UHPs: *Vignettes*

- 1. Archimedes and the law of flotation.**
(The original "aha" experience).
- 2. Newton and the apple tree.**
(Actually told by Newton himself).
- 3. Count Rumford and the boring of canons.**
(Should present his own account of the demonstration in Munich).

Case Studies

- **Aristarchus of Samos and the determination of the distance to the sun.**

(The distance to the sun can be calculated in terms of the distance to the moon).

- **Torricelli: Finding the "weight of the atmosphere".**

(One of the first modern scientific experiments).

- **Galileo and the discovery of free fall.**

(He "diluted gravity" in order to test his hypotheses).

Confrontations

- **Galileo and the Church.**

(The story of confrontation between science and theology).

- **The wave-particle confrontation of light: from Newton to Thomas Young.**

(Is light a wave or a particle? This question took over 200 years to settle, only to be re-opened by quantum mechanics).

Dialogues

- **Copernicus and the Aristotelians**

(Does the Earth revolve?).

- **Priestley and Lavoisier**

(discuss the relative merits of phlogiston and oxygen theories).

- **A creationist confronts an evolutionist**

(The debate is about the theory/fact dichotomy).

Thematic Narratives

- **The story of force: from Aristotle to Einstein.**

(The notion of force, from Aristotle to Newton).

- **The Corpuscular Nature of Matter:**

(The idea of the atom: from Democritus to Bohr).

- **The Story of Quicksilver**

(The role of quicksilver in science).

Science Drama

- **The Age of the Earth Debate.**

(A serious debate between Lord Kelvin, Sir Charles Lyell, T.H. Huxley and Hermann von Helmholtz)

- **Count Rumford**

(The social, political and scientific adventures of Count Rumford in Munich).

- **An Evening with Einstein and Newton**

(Einstein discusses his theories of relativity with his great predecessor).

From Intuitive Physics to Star Trek:

**Large Context Problems (LCP) to enrich
the teaching of physics**

- **Teaching physics through large context problems.**

(This will be a small book).

- **Large Context Problems (LCP) to enrich the teaching of physics.**

(This will be a CD, or DVD).

TEACHING PHYSICS THROUGH LARGE CONTEXT PROBLEMS

- **CHAPTER 1: THE IMPORTANCE OF CONTEXT**
- **CHAPTER 2: THE PHYSICS CURRICULUM**
- **CHAPTER 3: THE PHYSICS CLASSROOM**
- **CHAPTER 4: CONTEXTUAL PHYSICS**
- **CHAPTER 5: HISTORY OF SCIENCE AND
THE TEACHING OF PHYSICS**

Book...

- **CHAPTER 6: THE IDEA OF THE LARGE CONTEXT PROBLEM.**
- **CHAPTER 7: THE DESIGN OF THE LARGE CONTEXT PROBLEM.**
- **CHAPTER 8: THE IMPLEMENTATION OF THE LARGE CONTEXT PROBLEM.**
- **CHAPTER 9: EXAMPLES OF LARGE CONTEXT PROBLEMS.**
- **CHAPTER 10: THOUGHT EXPERIMENTS AND CONTEXTUAL TEACHING.**

Large Context Problems (LCP) to enrich the teaching of physics

- **LCP 1: INTUITIVE PHYSICS AND MOTION**
- **LCP 2: MOTION AND THE PENDULUM**
- **LCP 3: GALILEO, NEWTON, AND ROBOTICS**
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- **LCP 4: MACROROBOTS FOR ENERGY
PRODUCTION**
- **LCP 5: THE ULTIMATE MACROROBOT:
A ROTATING SPACE STATION**

LCPs continued...

- LCP 6: PHYSICS ON THE MOON
- LCP 7 : JOURNEY TO MARS: THE PHYSICS OF TRAVELLING TO THE RED PLANET
- LCP 8: THE AGE OF THE EARTH AND THE SUN
- LCP 9: ASTEROID/EARTH COLLISIONS
- LCP 10: THE PHYSICS OF STAR TREK

LCP 1: INTUITIVE PHYSICS AND MOTION

- In this LCP we will test and challenge students' conceptual understanding of motion.
- History of science: Ideas of Aristotle, Galileo and Newton.

LCP 2: MOTION AND THE PENDULUM

- This context is based largely on "The Pendulum: Scientific, Historical, Philosophical, & Educational Perspectives", and
- On the work of the author and Don Metz (*The Ubiquitous Pendulum, The Physics Teacher*, (2003)). Almost all elementary kinematics and dynamics can be taught and/or reinforced.

LCP 3: GALILEO, NEWTON, AND ROBOTICS

- This LCP is based on four sources:

Galileo's "Two New Sciences",

G.B.S. Haldane's celebrated article
"On Being the Right Size", published in 1928,

Mel Siegel's, a robotics research professor,
"When Physics Rules Robotics"; published in 2005,

The author's updated version of the article
"Physics and the Bionic Man" published 25
years ago in *The Physics Teacher* and *New Scientist*.

LCP 4: MACROROBOTS FOR ENERGY PRODUCTION

- The macrorobots we will discuss are the Giant Wind Turbines (GWT) and the giant solar furnace in Southern France (GSF).
- Discussion of electricity, magnetism, mechanical energy, radiation, optics, wave motion, thermodynamics, solar energy, thermonuclear reactions, and BB radiation.

LCP 5: A ROTATING SPACE STATION(RSS)

- The design and the physics of a RSS is presented, based on *2001: Space Odyssey*.
- A tear-level system for training astronauts to go to the Moon and Mars will be investigated.
- The physics that is part of this context is dynamics and gravitational theory.
- History: Newton's description of satellite motion in the *Principia*

LCP 6: PHYSICS ON THE MOON:

- The physics of low gravity environment is investigated and the physics of living on the Moon discussed.
- Structures, mobility, astronomic observations, Olympic games, etc are topics investigated.
- The physics involved is elementary kinematics and dynamics, the strength of material discussed in chapter 1.

LCP 7 : JOURNEY TO MARS: THE PHYSICS OF TRAVELLING TO THE RED PLANET

(This LCP is based on my article of the same title, published in *Physics Education*, 2005).

- The history of the importance of Mars to the understanding of the solar system.
- Several scenarios to travel to the red planet will be described and the physics of the journey explained.
- An interactive computer program will allow students to plan their own journey.

LCP 8: THE AGE OF THE EARTH AND THE SUN

(This LCP is based on my article of the same title, published in *Physics Education* in 2002).

- Review of main attempts made to calculate the age of the earth and the sun, from Newton's thought experiment to Bethe's thermonuclear model of the sun's energy
- Special attention is paid to the debate about the age of the earth in the second half of the nineteenth century that involved Kelvin and Helmholtz.

LCP 9: ASTEROID/EARTH COLLISIONS

(This LCP is based on the article of the same title, written with Don Metz, that was published by *The Physics Teacher*, in 2002).

- The physics of asteroid/Earth collisions will be discussed.
- The physics of a simple computer model for "impact scenarios" will be developed.
- Several famous collisions (Tunguska, Yucatan) presented in detail.
- The energy of the recent Tsunami will be compared to an asteroid collision of average size.

LCP 10: THE PHYSICS OF STAR TREK

(Based on an article of the same title, written with Ian Winchester. Published in *New Scientist* 1981).

The study of motion in the three regions of physics:

1. Speed of less than 10% the speed of light (Newtonian),
2. Speeds greater than 10% but less than the speed of light (Einsteinian),
3. Speeds greater than the speed of light (superluminal, or tachyon-like).

CONCLUSIONS: What we have done in Manitoba

- In the recent physics curriculum reforms in the province of Manitoba history of science has been incorporated to provide a more humanistic approach to learning physics.
- In *senior one* students investigate historical models of charge and build and perform experiments with historical apparatus such as the electrophorous.
- In grade 11 the historical development of the model of light is used as a backdrop to study models in general, as well as laws, and theories explicitly.
- Several historical case studies (such as the life of Madam Curie radiation, the history of rock and roll (electromagnetism), and the Doppler effect) have been developed by our teachers which can be implemented in the classroom.