**Mileposts and Heroes:**

**A Brief (and idiosyncratic) History of Science Education**

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Lane Community College, Eugene, Oregon

Kip Ault, Professor Emeritus

Lewis & Clark Graduate School of Education and Counseling

ault@lclark.edu

[www.darwinianwhimsy.com](http://www.darwinianwhimsy.com)

*An \* indicates a hero!*

Milepost 1762

Jean-Jacques Rousseau, *Emile, or On Education*

The first time a child sees a stick dropped halfway in water, he sees a broken stick. . . . To know if it is broken, as it appears to be, how many things must we do before drawing it from the water or putting a hand to it? I would prefer that Emile never know dioptrics [the optics of a two lens telescope] if he cannot learn it around this stick.

The things a child says are not what they are to us; the child does not attach the same ideas to them.

Milepost 1854

Thomas Huxley, *On the Educational Value of the Natural Sciences*

The methods of all sciences are identical; and these are:

1. *Observation* of facts—including *artificial observation* which is called *experiment*.

2. *General propositions*—tying up similar facts into bundles called *comparison* and *classification*.

3. *Deduction*—making inferences from the general propositions.

4. *Verification*—process of ascertaining whether an anticipation [inference] is correct.

No boy or girl should leave school without possessing a grasp of the general character of science, and without having been disciplined, more or less, in the methods of all sciences.

A teacher who does not know really and practically know the subject will be afraid to wander beyond the limits of technical phraseology.

Milepost 1870s-1920s

Ernst Haeckel, *Ontogeny Recapitulates Phylogeny*

*The Biogenetic Law:* During its own rapid development . . . an individual repeats the most important changes in form evolved by its ancestors during their long and slow paleontological [evolutionary] development.

*Cultural Epochs Theory*: Just as each epoch of history advanced civilization in a cumulative fashion, child development progressed through stages that built upon each other. The child ought to recapitulate the history of society as understood by Western cultures in order to develop properly: hunter-gatherer, agricultural society, Biblical patriarchs, chivalric feudalism, industrial revolution, modern science and mathematics.

*Stages of Cognitive Development*: Jean Piaget accepted recapitulation, but argued that the child’s development recapitulated not historical epochs but rather the history of the intellect from sensori-motor reasoning to formal logical operations. Piaget viewed logical reasoning as an extension of biological adaptation—an advanced stage of development, the adult mind derived from its immature stages.

Milepost 1910

John Dewey, *Science as Subject-Matter and Method*

*Recapitulating (Experiencing) the Logic of Inquiry*: Dewey argued that a student ought to experience (in effect, recapitulate) the logic of action pursued in the course of original inquiry. For Dewey, an episode of inquiry in the curriculum recapitulated the important stages of the original.

For Dewey, the future of civilization depends upon teaching “the scientific habits of mind.”

Dewey’s Scientific Method

1. Feel the difficulty of the situation.

2. Locate and define this difficulty.

3. Suggest possible solutions.

4. Examine the implications of these solutions.

5. Conduct further observation and experiment leading to a solution’s acceptance or rejection.

“The” Scientific Method Googled

1. Form a question from observation.

2. Hypothesize an answer.

3. Design an experiment to test the hypothesis.

4. Accept or reject the hypothesis based on the analysis of the data.

5. Propose and test a new hypothesis.

Milepost 1911

\*Anna Botsford Comstock, Lesson 106: The Garden Snail, in *The Handbook of Nature Study*

1. Can the snail pull in one eye and leave the other out?

2. How many spiral turns are there in a snail shell?

3. Place a snail on its back and see how it rights itself.

4. Look for the transparent, glistening snail eggs fastened together by mucuous.

5. Can you find the opening through which the snail breathes?

Milepost 1950

Harry S Truman signs legislation establishing the *National Science Foundation* (NSF).

Science teaching becomes an imperative of national security.

Milepost 1957

The Soviet Union launches *Sputnik* (“fellow-traveler”), reinforcing Truman’s message.

Milepost 1962

\*Joseph J. Schwab, *The Teaching of Science as Enquiry*

*The Conception of the Structure of a Discipline*; engage in inquiry and discussion; dismiss teaching as a “rhetoric of conclusions.”

Milepost 1960s-1970s

The “Alphabets”

Science A Process Approach (SAPA), Physical Science Study Committee (PSSC), Biological Science Curriculum Study (BSSC), Elementary Science Study (ESS), Earth Science Curriculum Project (ESCP), Science Curriculum Improvement Study (SCIS), Introductory Physical Science (IPS).

Milepost 1965

\*David Hawkins, *Messing About in Science*:

*Phase O*: a time for unstructured, open-ended play while teachers observe the children’s work.

*Phase Δ*: a time for differentiating work by identifying and pursuing multiple possibilities based on observations.

*Phase ▢*: a time for unpacking and verbalizing theories that have developed, through discussion among children and teachers.

Milepost 1967

Robert Karplus and Herbert D. Thier, *A New Look at Elementary School Science: Science Curriculum Improvement Study*

*The Learning Cycle*: Exploration of a Concept, Conceptual Invention, Concept Application.

Milepost 1978 CE

\*Mary Budd Rowe, *Teaching Science as Continuous Inquiry*: A Basic

Wait time, fate control, language development and science.

Milepost 1983

\*Rosalind Driver, *The Pupil as Scientist?*

Milepost 1983

National Commission on Excellence in Education , *A Nation at Risk: The Imperative for Educational Reform*

America’s enemies seem to have introduced the shortcomings of our schools; standards proposes which became “hijacked” (Dianne Ravitch) by testing.

Milepost 1986

The Holmes Group, *Tomorrow’s Teachers*

5th year of education for initial teacher certification, create standards of entry to the profession; examinations and educational requirements that are professionally relevant and intellectually defensible.

Milepost 1987

BSCS, The 5E Model

Engage, Explore, Explain, Elaborate, Evaluate.

Milepost 1994

United States Congress, Goals 2000 Educate Americans Act

United States students will be first in the world in mathematics and science achievement.

Milepost 1995

National Research Council, *National Science Education Standards*, 8 content domains:

1. Unifying Concepts and Processes

2. Science as Inquiry Standards

3. Physical Science

4. Life Science

5. Earth and Space Science

6. Science and Technology

7. Science in Personal and Social Perspectives

8. History and Nature of Science Standards

Milepost 2002

United States Congress, *No Child Left Behind Act*

Mandates “highly qualified teachers” in subject fields

Milepost 2013

NGSS Lead States, *Next Generation Science Standards*

*3 Dimensional Learning*: Scientific and Engineering Practices, Crosscutting Concepts, Disciplinary Core Ideas.

And still to consider: STS, IOS, CEPUP, Achievement Disparities, Democratic STEM Teaching, STEAM, Social Justice, and Place and Community-based Education!

For Okhee, Kip and Kevin,

Thank you for taking the time to give thought to each of the following questions for our OSTA panel presentation.  The panel will consist of 5 members (hopefully) and be moderated. We will ask each panel member to answer a question before going on to the next question so that each panelist has an opportunity to respond to the same question.  We want to give equal time to each person.

With that said, the answers to questions 3-6 address the theme of our session. We’ve allotted 40 minutes for the panelists to answer these questions and 10 minutes afterward for table groups to ask one question each to the panelists.  Additionally, later when table groups are in discussion, we’ll ask you to join/rotate to various groups to give input and ideas.

Please introduce yourself with your current position and how you became involved in Science Education.  What inspired you to be involved in Science or Science Education?

Lewis & Clark emeritus professor/author; as an elementary teacher, I followed children’s interests back to graduate school and the study of several sciences, especially paleontology.

What strengths do you see in the Sci. Ed. (MAT) programs in which you’ve been involved?

The Lewis & Clark program was an intellectually ambitious cohort model grounded in a well-conceived, 9 month apprenticeship. We stressed the question, “To what end are you teaching?” I often shared the statement, “On your conception of understanding nearly everything else depends.” I expected graduates to rise to leadership positions in curriculum and instruction, be willing to take risks, and remain idealistic even when making necessary compromises.

 How do you feel you have influenced and inspired Science Education? (brag a little!)

I came to Lewis & Clark in 1987 to design, organize, and coordinate the new MAT in Science Teaching and collaborate with Glenellen Pace (and later Nancy Nagel) to create a corresponding MAT in Elementary Education. For 25 years I contributed to the pre- and inservice preparation of k-12 science teachers. In my last years at LC I worked with the College of Arts and Sciences to create an outreach program aimed at bringing first generation college students, often from minority communities, to campus during the summer as apprentices to undergraduates counterparts engaged in scientific research. I worked with OMSI and the Oregon Zoo to lead classes and workshops on informal science education. In retirement I have authored two books—one on my reservations about the NGSS and one simply an enjoyable (or so I hope!) set of essays telling Darwinian stories of elephant, whale, and bird evolution in fashion I call “serious whimsy.” Also in retirement I have taught month long workshops on “Geologic Reasoning” at Beijing Normal University (People’s Republic of China). I continue to have an interest in geoscience education, especially as its characteristic demands and distinctive methodologies challenge the orthodox conception of “the” scientific method.

What challenges or barriers do you or have you seen to current Science MAT Programs that would improve teacher candidate preparation?

At Lewis & Clark, I witnessed the demise of robust science, natural history, and integrated math-science-technology components in the preservice program. The cause was growth in the literacy, mathematics, special education, and ESOL credits for the degree—in large measure as a direct response to NCLB concerns communicated to our program by school administrators.

Dream:  If you could design the ideal Science Teacher Education program:

I’ve already lived my dream! First, as a founder and teacher (k-6) of the Children’s School in Colorado Springs and secondly as a member of an extraordinary teacher education faculty that had the opportunity to create new degree programs in the wake of the 1986 Holmes Group report (urging an end to undergraduate teacher education and replacing it with 5th year programs).

Greg Smith and I did design an MAT for middle school teachers that never happened. It was focused on place and community-based education, teaching for a sustainable future, and integrating sciences with other subjects

What would you include?

What would you exclude?

How will you recruit and inspire teacher candidates from diverse backgrounds?

How would you inspire Science Teacher Candidates during and after they’ve completed their program?

*I would struggle to put aside the quest for unity as a driver of curriculum design (the short lists of generic practices and themes). In place of asking, “What are the habits of mind common to all the sciences?” I would focus on the question, “How do disciplines respond to the distinct challenges of their respective problems?” “In what ways are the sciences unified?” may matter less than “Which sciences, and in what contexts, offer the most value to our social lives and personal interests?”*