Toward a Humanistic Science Education: Using Stories, Drama and the Theatre

By Art Stinner

Energy is eternal delight.

—William Blake

Energy is the ability to do work.

—Most elementary science textbooks

Any sufficiently advanced technology is indistinguishable from magic.

—Arthur C. Clarke (39)

[W]hat Quintus Horatius Flaccus said some 2000 years ago in his Ars Poetica *("*Lectorem delectando pariterque monendo,*" which translates as "delighting the reader at the same time as instructing him") is also true today. What is wrong with learning something while being entertained? In other words, why not use drama to smuggle (with a substantial dose of theatricality) important information generally not available on the stage into the minds of a general public?*

—Carl Djerassi

Introduction

The epigraphs for this article capture the essence of my motivation for introducing drama (science stories, plays, short dialogues, dramatized historical contexts) into the teaching of science. William Blake's poetic description of the notion of energy complements the simplistic scientific definition that students memorize without adequate understanding and can be used to show that, imbedded in the scientific principle of the conservation of energy, we find deep mystery. Arthur C. Clarke's statement reminds us of our utter inability to anticipate the scientific ideas and technological developments of the future. Finally, Carl Djerassi, a noted scientist and science dramatist, connects to an ancient writer and playwright who understood that instruction and learning is more fruitful in a context of entertainment. The first passage touches on the inadequacy of memorizing science definitions, the second dramatizes the complexity of the evolution of science and technology, a complexity that cannot be anticipated by a specifiable scientific method, and the third suggests that we learn best when we are entertained and our interest is aroused.

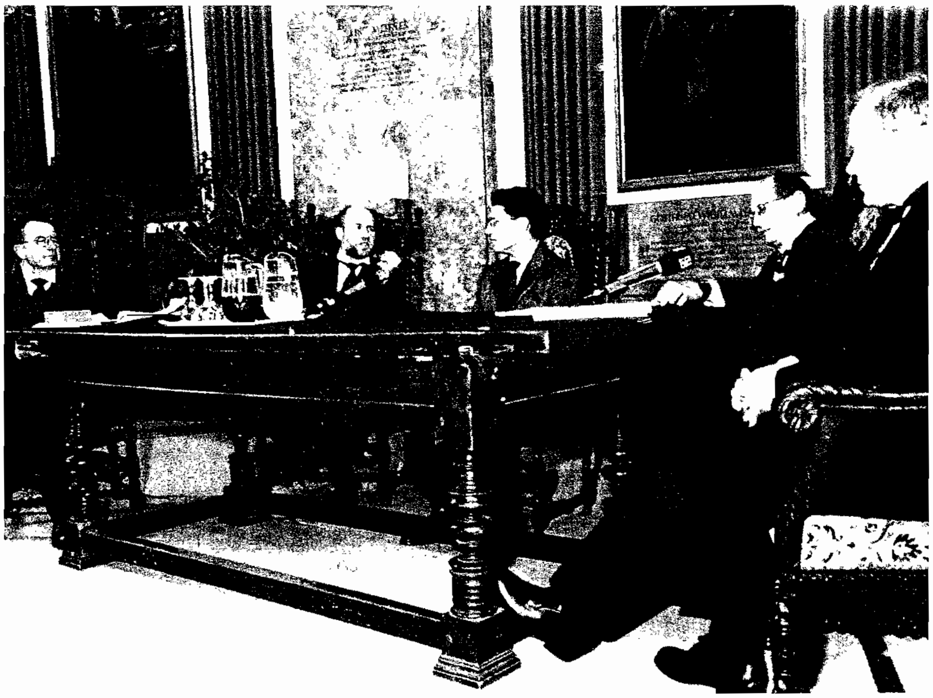
Linking Humanistic and Scientific Modes of Thought

There is a perceived split between the humanities and the sciences that is seen as having established two distinct and identifiable modes of thought. Arguably, this split can be traced back to Plato, but the significant parting of the ways occurred in the fifteenth century. There have been several re-examinations of the implications of this separation since then (Stinner, "Science Educator's View"). The latest public manifestation of it appeared just under fifty years ago in C.P. Snow's "two cultures" theory and F.R. Leavis's response to it (see Stinner, "Science, Humanities"). What is of concern, here, is that this separation seems to have been institutionalized, enshrined in our textbooks and consciously incorporated in our curricula. I will suggest that the science story and the dramatization of science may offer a partial reconciliation between the two modes of thought.

Most writers locate the roots of the "two cultures" split in the separation of branches of knowledge by the end of the fifteenth century. The two branches were the *trivium* (grammar, rhetoric and logic), relying on verbal methods of argument and Aristotelian syllogistic logic, and the *quadrivium* (arithmetic, geometry, astronomy and music, conceived as the study of acoustical proportions), relying on measurement and calculation in presenting arguments. The *trivium* approximated what we today call the *humanities*, and the *quadrivium* what we call the *sciences*. In the fourteenth century, by contrast, all scholars (natural philosophers and theologians) were thoroughly grounded in the full range of the liberal arts (consisting of both the *trivium and* the *quadrivium*) and shared the same realm of discourse.

The confrontation between the sciences and the humanities surfaced publicly, much later, in the Shelley-Peacock exchange of 1820. Thomas Love Peacock argued (mostly tongue-in-cheek) in his *The Four Ages of Poetry* that poetry had outlived its usefulness in the modern age of science. Shelley took the challenge seriously and responded with his much-discussed essay "In Defence of Poetry." Although he recognized the place of science, he argued that "not through reason (analysis), but through the imagination (synthesis) do we perceive the 'indestructible order' and harmony of the universe" (Jordan 70, quoting Shelley).

The Huxley-Arnold controversy of 1882 is based on an exchange of views contained in T.H. Huxley's lecture "Science and Culture" and Matthew Arnold's response in "Literature and Science." Huxley argued that science had completely reshaped our understanding of the universe and man. According to Huxley, therefore, the meaning Arnold gives for "culture" – "to know the best that has been thought and said in the world" – must include science (Arnold, qtd. in Stinner, "Science, Humanities" 16).



The first performance of *Das Alter der Erde (The Age of the Earth)* in November 2000 at the Deutsches Museum in Munich; (l-r) Hermann von Helmholtz, William Thomson (Lord Kelvin), the Moderator, Sir Charles Lyell and T.H. Huxley. In the background, we can clearly see large pictures of Leibnitz and Gauss. The bust of von Helmhotz is above Jürgen Teichmann (Director of Education of the DM), who played von Helmoltz
Photo courtesy of Art Stinner

The most recent public confrontation between the sciences and the humanities was initiated by the "two cultures" theory of C.P. Snow (Stinner, "Science, Humanities"). This theory (1959) is based on the assumption that the intellectual life of western society is increasingly being split into two polar groups, namely the scientists and the humanists. Between these groups, a gulf of mutual incomprehension exists. One culture, the scientific, should be thought of as continually in flux, incorporating new discoveries on the basis of general agreement and verifiability. The other culture, the humanistic, changes but does not depend on collective agreement, since its emphasis is on content not process. If Snow's picture of science is correct, then the problem of what it is to be literate in the sciences and the humanities consists in specifying the "pillars" of each scientific and humanistic discipline, determining how these pillars are related and finally suggesting ways of bridging the gap between them. Science as an activity, however, cannot be pinned down by a specifiable general method, contrary to what Snow seems to have suggested. As Jacob Bronowski so eloquently argued, high-grade thinking in science involves a creative action utterly dependent on human imagination, not unlike that involved in the creativity associated with artistic and humanistic activities.

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As a science educator, I am interested in designing contexts, stories and dramas that generate questions and problems that naturally involve both the humanities and the sciences. Teaching of this variety can be thought of as a response to the quest to "bridge the gap" between the sciences and the humanities. However, this must be accomplished in a less contrived way than is possible in courses such as "poetry for physics students" or "physics for poetry students." Finally, I am interested in what kinds of scientific and humanistic literacy recognizes a common ground between the sciences and the humanities.

The influential American educator Jerome Bruner, however, believes that there are two irreducible modes of thinking, namely the *paradigmatic* and the *narrative* modes. These two modes of thought allow us to order experience and construct reality: the paradigmatic (the scientific or logico-scientific) and the narrative (the humanities). The narrative mode is divergent and employs literary devices, such as stories and plays, to express meaning. Bruner argues that these two modes of thought, although complementary, are irreducible to one another.

Bruner's student, the noted Canadian cognitive scientist and educator David Olson, on the other hand, is more conciliatory. He believes that, while supporters of C.P. Snow think of them as two incommensurable cultures, "the humanities and the sciences live side by side without seriously challenging one another" (165). He goes on to argue that the demarcation between the human and the natural sciences is based on their object of study and not on their epistemologies. This, he believes, implies that training in the sciences should take place through the humanities.

Science Stories

Although it is important to be '"historically correct,'" poetic licence can be taken in designing the story (remember that the story of the leaning tower of Pisa is apocryphal, whereas Newton and the apple tree is a story told by Newton himself). Science, of course, is more than a collection of aha-experiences – it cannot be reduced to a series of dramatic insights. The vignette depicting the moment of insight does little to contribute to our understanding of the scientific creative process. However, a good understanding of the events and the ideas that, at least in retrospect, made that event seem almost inevitable is probably necessary for our complete understanding of the creative element in science. Moreover, scientific work is difficult, often arduous and boring, with diverse connections that only the initiated really understand. However, I am arguing that the dramatizations of key achievements, such as the ones mentioned, can provide great motivational settings in which to study science.

In summary, I am advocating that an appropriately designed science story and drama provide an integrated approach to teaching that emphasizes diverse connections between the humanities and sciences and encourages an individual's attraction to an important aspect of the world. In addition, science stories must consciously incorporate a "scientific element" and a "humanistic element." Even for the simple retelling of "eureka stories," the crafting of the story is a humanistic, creative process. We can invent stories, but they must be well placed in history.

The proper historical placing requires that events, ideas and experiments should be plausible in a given historical setting. For example, a physicist knows that the theory of relativity allows travelling into the future (the "twin paradox") yet prohibits travelling into the past because that would violate the principle of causality. However, while poetic licence allows us to send a student from the twentieth century back to the third century BCE, we cannot allow him or her to take back in time a pocket calculator to impress Archimedes. On the other hand, even this restriction may not be appropriate or necessary in early-years science. Bruno Bettelheim showed us that fairy tales are powerful vehicles in capturing and shaping the imagination of the young mind and G.K. Chesterton gave us a convincing argument of the internal logical consistency of the fairy tale in his "The Logic of Elfland." The final version of the "science story" then might include both those that are based in historical context and those that are free invention or application of the science-educator inspired by both the humanistic and scientific disciplines. High-grade thinking in science then involves a creative act utterly dependent on the human imagination, not unlike that involved in the artistic and the humanistic activities (Stinner, "Science, Humanities). Elliot Eisner writes, "The scientist, like the artist, must transform the content of his or her imagination into some public, stable form, something that can be shared with others" (26).

The *Das Alter der Erde* (*The Age of the Earth*) cast at the Deutsches Museum in Munich. 2000; Jürgen Teichmann, professor and director of programs Deutsches Museum (Hermann von Helmholtz), Arthur Stinner (author), Wilhelm Wossenkuhl, professor of philosophy and chancellor of the University of Munich (Moderator), Harald Lesch, professor of astrophysics, University of Munich (Kelvin), W. Altermann, professor of geology, University of Munich (Charles Lyell) and B. Grothe, researcher in biology, Max Planck Institute, Munich (T.H. Huxley)
Photo courtesy of Art Stinner

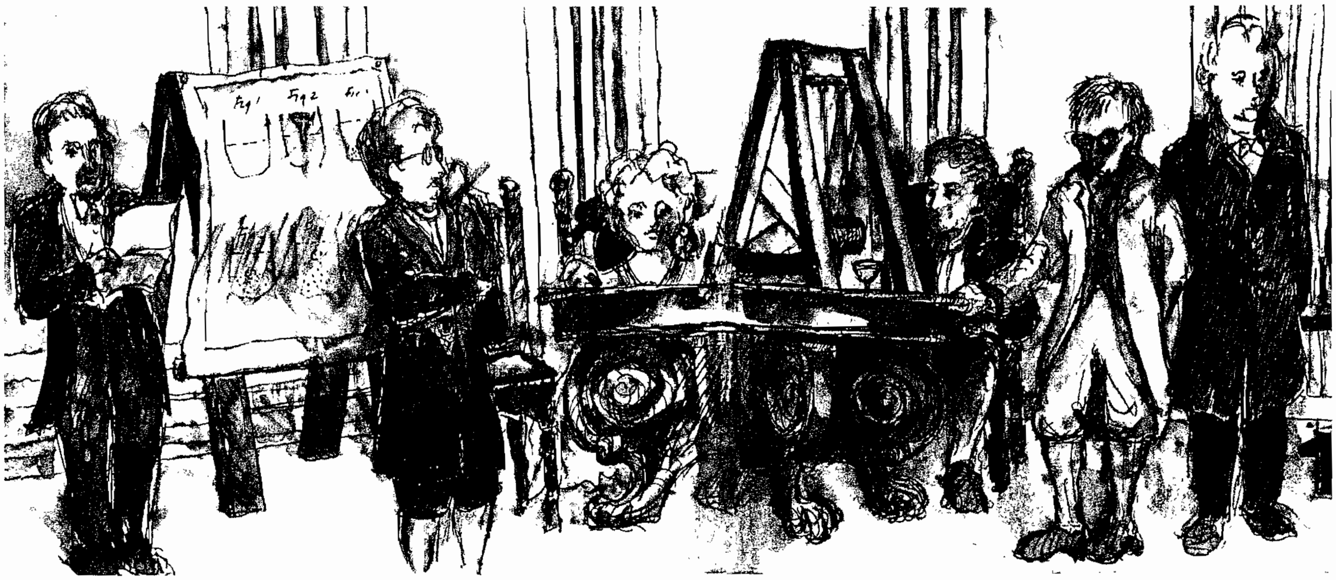
Science and the Theatre

Since World War II, there have been many dramas written that focused on the role scientists ought to play in society. I recommend the excellent review of this topic that can be found in "The Image of the Physicist in Modern Drama" (parts 1 and 2) by the Canadian physicist and physics educator Wytze Brouwer. Brouwer discusses plays such as Brecht's *The Life of Galileo*, Dürrenmatt's *The Physicists* and Kipphardt's *In the Matter of Robert Oppenheimer*, to name only a few. He argues that, in most of these plays, the scientist is portrayed sympathetically, but research is viewed as much more of an individual activity than it is in actual practice. He concludes the second article by suggesting that "these plays serve as an excellent introduction to a discussion of the social responsibility of scientists, and scientific organizations, and might form a useful element in the ethical education of scientists or science teachers" (239).

More recently, the international success of the plays *Oxygen* by Carl Djerassi and Ronald Hoffmann and *Copenhagen* by Michael Frayn suggest a wide public interest in the history of science as well as in science itself. The first is a two-act play that tries to answer the question, "Who discovered oxygen?" The play is also about doing science, politics and ambitions. The second play is based on the meeting between Bohr and Heisenberg in 1941 in German-occupied Denmark where they discussed the possibility and consequences of harnessing nuclear power. The play is also about loyalty, suspicion and friendship. The setting for *Oxygen* is based on a fictional encounter between Lavoisier, Priestley, Sheele and their wives, at the invitation of King Gustav III. The place of the discussion is Stockholm, in the year 1777. The central question is, "Who discovered oxygen?" The setting for *Copenhagen* is more modest: Heisenberg is in the home of the Bohrs, with Mrs. Bohr as an important participant. Here the central question is, "Why did Heisenberg come to Copenhagen?" Both plays have been praised for the excellence of their dramatic design as well as for the correctness of their historical and scientific content. They received high acclaim from historians of science and scientists alike. What is important is that both plays have elicited much public and academic discussion.

What Can Theatre Do for Science?

Most of the authors mentioned above are not scientists, with a few notable exceptions, such as Carl Djerassi. The well-known plays by Brecht and Dürrenmatt mentioned earlier express scepticism about science, in the context, for Brecht, of the well-known confrontation of the Church and science and, for Dürrenmatt, of the fear of nuclear war. Dürrenmatt places Newton, Einstein and Moebius in an insane asylum and uses this as a metaphor for describing the world of the physicist. Heiner Kipphardt, in his play about Oppenheimer, tried to present similar concerns, but by using science to educate the public. The successful contemporary playwright Tom Stoppard seems very interested in the science involved in his plays, but he uses science and scientific concepts mainly as metaphors. It is to his credit that he is able to write a very clever whodunit using the photoelectric effect and Heisenberg's Uncertainty Principle. In Canada, we have Maureen Hunter's *Transit of Venus*



A sketch made during the performance of the Rumford play in Munich 2002
Sketch by Ann Stinner

and Vern Thiessen's *Einstein's Gift* as examples of successful attempts to present concepts in astronomy and chemistry respectively.

My own efforts to incorporate drama, dialogues and plays into my program of teaching science education and the history of science to teacher candidates at the University of Manitoba started modestly with simple interactive historical vignettes and short dialogues between scientists. The success of these led me to write science plays. The first one was *The Age-of-the-Earth Debate*, which was performed in Italy, Munich and Canada. The second play was based on the fantastic life of the scientist–soldier–politician–adventurer, the American Count Rumford, who lived and worked in Munich for more than a decade toward the end of the eighteenth century. This play was also performed at the Deutsches Museum in Munich and then again (in English) at the 2003 IHPST (International History and Philosophy of Science Teaching group) conference in Winnipeg. Finally, my latest play, *Einstein contra Newton*, was recently (2005) presented at the Deutsches Museum on three occasions, again to sold-out audiences. Finally, we are planning to present the English version of the Einstein play, entitled, *An Evening with Albert Einstein and Isaac Newton* at the upcoming IHPST conference in Calgary in June (for details, see my Web site, <http://www.ArthurStinner.com>, where texts of most of these plays can be downloaded).

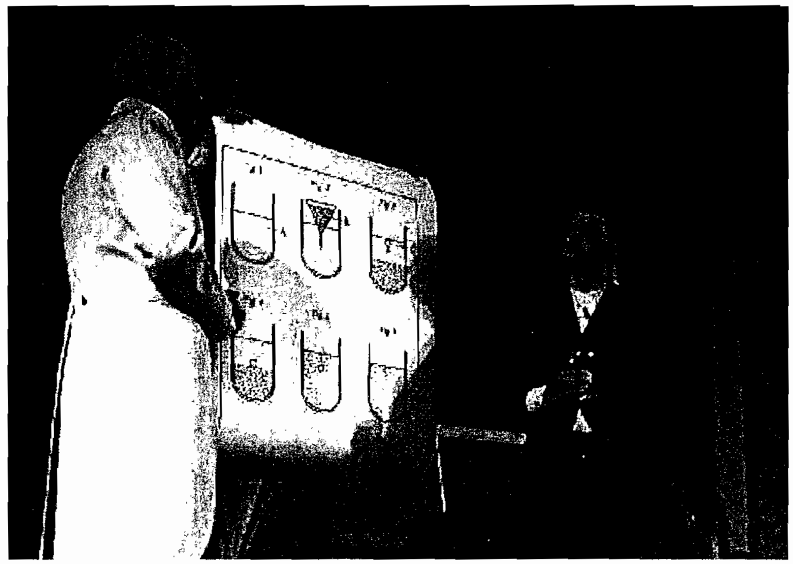
What may be unique in these dramatizations performed publicly is that the *personae dramatis* are (and should always be) professors or practising scientists in the appropriate disciplines. These experts should first acquaint themselves with the original script and then research the history of science for the period of the debate being staged. This double preparation allows them not only to present the ideas with authority and authenticity but also to go beyond the text and respond spontaneously to the demands of the moment. Going beyond the text produces unexpected responses – often humorous, sometimes emotional – clearly showing the human side of science. Indeed, the numerous digressions to the blackboard to illustrate the ideas in the plays add interest to presentations that might otherwise be static conversations around a table. Finally, the moderator can be someone who represents the intelligent lay person so that the drama resembles a contemporary talk show.

In our effort to place the history of science in the teaching of science, we have developed what we call "units of historical presentation." This is not an exhaustive list but includes most approaches used in placing science in context and in presenting the history of science (Stinner et al.): vignettes, historical contexts, historical case studies, confrontations, thematic narratives, dialogues and science dramas (see our Web site for details <http://www.sci-ed.ca/>).

Concluding Remarks

This article turned out to be a continuation and an updating of the material from three papers, one old and the other two fairly recent (Stinner, "Humanistic"; Stinner et al.; Begoray and Stinner). The first one can be obtained from the journal *Science Education* and the second and third can be downloaded from my Web site.

I am also interested in public education in science. Theatre can be used to present important ideas in science, as described earlier in connection with successful science dramas. The science play *The Age-of-the Earth Debate* is my favourite: it fulfils the requirements of being good drama and telling authentic history of science (Stinner and Teichmann). The audience is entertained and, at the same time, learns how the established discipline of physics and the emerging disciplines of biology and geology were forced to collaborate in an effort to answer the question of the age of the earth and the sun. As a physics educator, I readily admit that this is the story of the arrogance of physicists who believed, as Lord Kelvin expressed it (looking the biologist T.H. Huxley straight in the eye): "[b]ut we know everything about the physical laws of the universe!" When my students (future science teachers) read this passage aloud in class, the scene never fails to delight the biology majors, since it is clear that the physicist Lord Kelvin was wrong and the biologist Huxley was right about the age of the earth. (Unfortunately, neither man lived long enough to find this out).



Count Rumford discusses the idea of convection with the Duke, Karl Theodor.
Photo courtesy of Art Stinner

Finally, I would like to emphasize that the contextual story-line approach proposed here does not de-emphasize the scientific or quantitative aspect of the world. Nor should context-based learning be inadequate in providing basic content knowledge of the textbook kind. On the contrary, the contexts can be so designed that the measuring, experimenting and data-collection required are an integral part of the problems and questions generated by the contextual setting. There must be a consciously incorporated progression from early years to senior years in the design of contextual and story-like settings to ensure secure and adequate imparting of quantitative skills and basic factual knowledge. In the early years, students should choose, determine and generate contexts, "guided" by the research director – the teacher. In the senior years, the teacher should design large context problems, with students expanding and generalizing according to personal interest (Stinner, "Humanistic"). Textbooks can then be used, but as reference material only.

Ultimately, one can envisage science being taught by way of context and science stories from the early years right through to senior high school. Towards that end, science curricula will have to be significantly changed, assessment in science rethought and textbooks rewritten and their role reconsidered. Moreover, practising teachers will have to be retrained and new teachers be trained in designing and implementing contexts, writing and using stories and presenting science dramas that are appropriate and interesting to the student. Contextual teaching based on a story-line approach could then go on until specialization becomes inevitable.

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