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INTERNATIONAL PERSPECTIVES ON SCIENCE EDUCATION

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Since the 1983 publication of *A Nation at Risk* (National Commission on Excellence in Education), comparisons of the American education system with those of other countries have become commonplace. Hundreds of articles on the subject have appeared in the popular, professional and academic literature, as well as in a number of books. Comparisons have also been driven by the “America 2000” campaign. The challenge to science educators in this campaign is explicit: “By the year 2000, United States students will be first in the world in science and mathematics achievement.”

What remains unclear for many educators is how comparative education can be used to improve our schools. The vast majority of comparisons are used solely to determine our relative success or failure. However, we must go beyond the quantitative comparisons of test scores that make exciting headlines. In addition, the value and validity of these measurements have been protested (Rotberg 1990). Unfortunately, greater emphasis (and research funding) has been placed on these types of comparisons than on studies in foreign classrooms which can give us valuable insights into effective instruction.

We have also been confronted with the task of developing “world class schools.” Just exactly what constitutes a “world class school” has never been particularly clear: there is no consensus on what a world class school looks like as I reported to an Iowa State Legislative Study Committee in 1991 (Grey 1991). The present article responds to requests for similar discussions specific to science education. It is an attempt to articulate the implications of comparative education for science education.

The recent flurry of comparisons between American schools and those abroad is by no means the first example of this activity. Many in the science community in particular will remember the 1961 book, *What Ivan Knows that Johnny Doesn’t*, published after the successful launch of the Soviet satellite *Sputnik* (Trace 1961). That emergency spurred a tremendous revitalization of science and math education unparalleled until
recently. Today, however, most comparisons are made with Japan and Europe. Interest in Japanese education in particular was sparked by a growing trade deficit with that nation and concerns about our ability to remain competitive in the global marketplace. These concerns are well founded, as Fisher (1992) forcefully argues with a series of what he calls “alarming” statistics. Others have noted that in an “exchange of critiques of each other’s economies, the Japanese finally... hit us where we are most vulnerable. . . . If the U.S. is to remain economically competitive, our secondary education system must upgrade the teaching of math, science and foreign languages” (Lewis 1990:340).

While many have attributed Japan’s competitive edge to the educational preparation of its work force, others have referred to the “yes ... but” approach to introducing Japanese practices in our schools. In this approach, we acknowledge Japanese success but then argue that these accomplishments come at a price Americans are unwilling to pay (Tobin 1986). However, the balance of literature on Japanese education does emphasize the valuable lessons we can learn from their experience. For example, their emphasis on strong primary education is touted, as well as a school year that is 60 days longer than our own. The integrative nature of their science and math courses is noted, as well as the use of an essential curriculum that contrasts with our emphasis on electives at the secondary level (Cummings 1989).

The Japanese have also been credited with “valuing” education more than Americans and demanding more of their students. However, our task is to make these “cultural factors” relevant to life in the classroom. For example, some scholars have noted that while Japanese parents may consider an activity with their children a “game,” Americans may understand the activity as a “test.” The former emphasizes the process of learning and the latter emphasizes the outcome and whether it was correct or wrong.

How is this cultural manifestation reflected in the science classroom? Japanese science teachers tend to admit the formulation of a variety of hypotheses, allowing the submission of different “answers” to the same problem. Hess and Azuma (1991) refer to this process as “sticky-probing.” This approach involves selection of a seemingly small problem that most of children would not otherwise notice, probe into it through deliberate group discussion and teacher-pupil exchange, and thus spend considerable time on reflecting, examining and digesting the problem. . . . They are expected to probe, to stay with a topic, and to examine an issue from several
perspectives, rather than to push quickly for a solution or "correct" answer (Hess and Azuma 1991:6).

One study provides a valuable illustration of the contrasting practices of Japanese and American teachers in science education (Azuma and Walberg 1985; Hess and Azuma 1991). Four fifth-grade teachers in each country were videotaped as they taught their students about, and conducted an experiment in, dissolution of substances in water. In all of the American classes, discussion centered around planning the experiment, procedures to be followed and precautions that had to be taken. The teachers asked questions that could be answered in brief responses and the interchange moved quickly. As the researchers noted,

Convergence of ideas was not a goal. Often the teacher allowed the discussion to end without a summary statement or conclusion. The American classes that we observed were clear and snappy, encouraging divergent fluency. "Anything else? Anything different?" was the stimulus to which children kept responding. The discussion kept moving on, as if to linger on the same phrase or idea might threaten fluency or lose the students' attention (Hess and Azuma 1991:6).

In contrast, the observed Japanese science classes took much more time to discuss a "substantive" question, such as how to ascertain the density of a salt solution without testing it, whether or not some of the weight of the substance would get lost when dissolved in the water, whether salty taste is evidence of salty substance. . . . The teacher probed and focused, seldom gave clear feedback and kept his own position vague. At the same time he made sure that the discussion concentrated on the problem he posed at the beginning. After a lengthy discussion that divided the class into groups holding different opinions, an experiment was planned and executed as a means of resolving the conflict (Hess and Azuma 1991:6).

In this case, the American approach concentrated on specific outcomes, while the Japanese concentrated on allowing the creation of varied answers to problems and group approaches, thus emphasizing the process of learning. As a result, this approach also de-emphasizes multiple choice and short answer examinations.

Also note that the role of the experiment itself is different. In the American case, the experiment was used to come up with the answer
without soliciting creative responses from students. In the Japanese example, however, the experiment itself was planned and undertaken by the class itself after extensive discussion of several different possible resolutions to transpose the problem at hand.¹

The Japanese approach to science education illustrated here also emphasizes “team” learning in which students are encouraged to work together instead of competing against one another. This may seem to run counter to our cultural emphasis on one’s ability to take the initiative and be an individual, but one important part of school life throughout our society provides the ideal model for collective learning: team sports. The importance of achievement in team sports overrides values of separateness and individuality usually found in the classroom. Imagine how academic achievement would thrive if the public placed as much importance on team performance in the classroom as that placed on sports.

Such enthusiasm is demonstrated in other countries. One writer likened the Japanese media coverage of academic achievement to that of sports in the United States (Lynn 1988). For example, the high schools which place the highest percentage of students in the nation’s most prestigious University of Tokyo are listed in newspapers and the top twenty schools announced on television news.

Similar manifestations are found in France and Britain. British newspapers routinely comment on the performance of the most successful students, and in France the year’s best exam answers are published in national newspapers (Bruce 1991).

Other lessons of comparative science education emphasize the need for more integration of science curriculum—a need that has become increasingly recognized and encouraged by American science organizations as well.

However, integration of science curriculum has already been actively promoted by international organizations in the past and is widely practiced elsewhere. For example, the United Nations Educational, Scientific and Cultural Organization (UNESCO) actively analyzed and promoted integrated science curricula in the 1970s through publication of a series of monographs titled *New Trends in Integrated Science Teaching.*² This series noted the world-wide growth in integrated science education, particularly at the primary and lower-secondary school levels. “Almost all primary science courses are based on direct pupil experience and exploration of the environment . . . [And] the significance of science education as
a component of general education... has found wide-spread acceptance” (Haggis and Adey 1979:37).

But what is the rationale for integrated science curriculum as promoted by UNESCO? We accept that education is an attempt to provide knowledge of the world, and we usually do this by breaking down this enormous amount of knowledge into a system of “subjects” of which science is one component.

However, analyzing knowledge in this way, and presenting it in elements that are subjects, does not help students to synthesize their learning into the global view... that is our aim. Integrated science is a step in the direction of restoring, at least at some educational levels, an integrated view of the environment, but science is only one of the elements, and by itself cannot provide an understanding of the “real world” outside school in its full nature and socio-economic context” (D’Ambrosio 1979:29).

Clearly, we must do away with the so-called “layer cake” approach to education in which students take biology one year, chemistry the next and few or no connections are drawn between them or other fields.

The International Association for the Evaluation of Educational Achievement (IEA) undertook a recent study of science achievement in twenty-three countries which has been widely cited in the popular and professional literature (Postlethwaite and Wiley 1992). However, this organization has also recognized the value of international comparisons of educational practices, not just outcomes. Their essential aim “was the collection and analysis of data that would result in the improvement of science education in the countries that participated in the study” (Rosier and Keeves 1991:3). Their review of science curricula around the world is thorough and provides valuable insights into their design and implementation.3 While all countries plan and implement science curricula that reflect local cultural, economic and political realities, the study sought to identify good policies and practices.

In terms of what all students should learn about science during the years of mandatory schooling, there is growing recognition that the processes of inquiry are of increasing importance, and as a consequence, process objectives are given prominence in the science curricula of some countries, and greater emphasis at this stage than at the upper primary school level. Similarly, it is recognized in most countries, but not all, that all students during the years of mandatory schooling should study content from the three main fields of science [biology, chemistry and physics] (Rosier and Keeves 1991:77).
The science education of the largest student population was addressed as well: those who will enter non-science related fields after graduation from secondary school. Given the greater impact of science and technology on society, it would seem desirable that non-science high school students should have some understanding of relationships between science, technology and society... However, little consensus has emerged as to the nature of such courses.... This is an aspect of science curriculum that urgently needs attention (Rosier and Keeves 1991:79).

Are there any particular lessons we can learn from the review of science education in other nations? First, we can learn how not to proceed. For example, while we admire the classroom approaches of Japanese science teachers, the emphasis upon examination performance in the Japanese education system creates "intense competition" (Altbach 1989:245) in an environment often referred to as "examination hell." The competition is so intense that 60 percent of Japanese primary school students enroll in extra enrichment course (Ranbom 1985). While Japanese corporate leaders were "grateful for a superbly skilled work force that has powered their economic miracle. They are now singing a slightly different tune" (Ranbom 1985:20). As one manager for recruitment and development at the Mitsubishi Corporation stated about applicants he interviews, "I see a lot of narrowly focused, standardized individuals" (Ranbom 1985:20). Clearly, we must strive to create a balance between fostering creativity in the classroom and examination performance.

There are valuable lessons to learn from an international perspective. I believe the primary lesson is that we must reexamine our underlying assumptions about schooling. As a teacher educator, I am continually troubled by the presumption on the part of students and practicing teachers that our ("American") model of schooling is the only model available and, therefore, the prototype for all other schooling in the world. This is not the case, but as long as teachers (and administrators) continue to act as if it were, we can not expect to learn from international experiences.

We have been challenged to reform our schools, but this is a slow and difficult process. I contend that individual teachers can begin the process in their own classrooms without having to wait for institutions to catch up. Perhaps in no other field is this more possible or appropriate than science. Learning from our foreign colleagues is a good place to begin.
Notes

1 Here is one suggestion for experimenting with this type of approach in our secondary schools: ask students to come up with three ways to determine the difference between regular soda and the sugar-free variety without tasting it (Ahlgren 1991:48).

2 The fifth volume in the series (Reay 1979) also has an extensive bibliography in trends in integrated science.

3 National case studies are provided for 23 countries: Australia, Canada, China, England, Finland, Hong Kong, Hungary, Israel, Italy, Japan, Korea, The Netherlands, Nigeria, Norway, Papua New Guinea, Philippines, Poland, Singapore, Sweden, Thailand and the United States. Mexico and Tanzania were initially involved in the study but later withdrew.

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