SCIENCE LITERATES *OR* SCIENCE EXPERTS?

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The results of science achievement studies for New Zealand highlights a common teaching dilemma

At national and international levels concerns exist over the declining status of science in society and the general decline in recruitment to scientifically based careers. At the same time there is a growing need for a scientifically literate citizenry. Every day, the media inundates us with information about scientific topics: ozone depletion, the greenhouse effect, gene and reproductive technologies, forensic science, and space exploration, among many others. People need to be able to make personal and social decisions about these topics, as well as participate in public debates and decision making.

So what is the goal of science education, to recruit candidates for careers in the sciences or to educate the masses for functional scientific literacy? These seem at times to be conflicting goals. By broadening the base of science education and teaching for general science knowledge rather than expertise in any one area, educators are often accused of "dumbing down" science to the point where specialist talent is lost (Bell et al, 1997; Hurley, 1998). But by exposing more students to science at a basic level, educators increase the probability that some will choose science as a career. Adulation of excellence and awe of the specialist should not blind us to this reality. Sacrificing science literacy in favor of science expertise produces a society in which science is viewed as alien to general needs and comprehensible only to a select few.

Studies such as the Third International Mathematics and Science Survey (TIMSS) indicate the need for science literacy (Beaton et al, 1996; Gardener, 1996; Mullis et al, 1998). This study, which took place between 1992 and 1997, was carried out under the auspices of the International Association for Educational Achievement (IEA). The study included assessment of the mathematics and science achievement of students in years 4 and 5, and 8 and 9, as well as assessment of literacy in mathematics and science of senior secondary students in more than 40 countries or education systems (Walker and Chamberlain, 1999).

The 1996 and 1998 TIMSS findings created controversy in both the United States and New Zealand. Educators in both countries were disappointed with the performance of their students, and debates hinged on the ability of the education systems to produce excellence rather than failure or mediocrity in science. But without a clear set of desired outcomes, such as general scientific literacy and/or specialist training, the debaters may not even be speaking the same language, and any resulting policies may be contradictory and lead to dysfunctional science education programs. Thus, a desired final outcome of a scientifically literate population from which science specialists can be recruited and trained, requires different resourcing and teaching methods than does an outcome of simply finding and training those individuals who already show interest and talent in science.

Science achievement in New Zealand

The need for clear goals has been evident in New Zealand. In June 2000 the New Zealand Education Review Office (ERO) published "Planning for the Future," a report that outlined the results of a survey carried out by the ERO office of mathematics and science education in Korea, Singapore, the Netherlands, and Ireland (Education Review Ofiice, 2000). Students from all four countries scored high on the TIMSS, but New Zealand's scores for the 9 and 13-year-old cohorts (grades 4 and 8) tested, were not significantly different from the international average.

Scientific literacy comes before, not instead of, specialization

The ERO report uses this comparison to illustrate how the New Zealand system is failing to meet the needs for science and mathematics education. The four systems examined for the report, however, are very different from the New Zealand Education system. The selection of students, the combination of curricula, the underlying culture of academic excellence, the multicultural aspect of the population, as well as teacher training requirements, can all be quoted as reasons for the observed differences in achievement in the middle school years. The Netherlands was the only nation in the ERO-chosen sample that provided data for the senior school literacy survey. Thus, a comparison between early achievement and science literacy in the senior school is not as meaningful as a comparison with the results from a nation, such as the United States, more similar to New Zealand in culture and systems (Beaton et al, 1996).

In Figure 1 this has been contrasted with the scores for U.S. students in the same cohorts. The students in

FIGURE 1

Percentages of students achieving international marker levels in science in grades 4 and 8.

Country	Mean achievement		Top 10% level		Top quarter level		Top half level	
	Grade 4	Grade 8	Grade 4	Grade 8	Grade 4	Grade 8	Grade 4	Grade 8
New Zealand	531	525	9	11	22	26	47	51
United States	565	534	16	13	35	30	63	55
International Avg.	524	516						

(BEATON ET AL, 1996)

FIGURE 2

Distributions of science literacy achievement for students in their final year of secondary school.

Country	Mean achievement
New Zealand	529
United States	480
International Avg.	500

(MULLIS ET AL, 1998)

the United States scored significantly higher than the international average and performed better at the top levels than did the New Zealand students. This is particularly noteworthy because New Zealand children attended school an average of 6 to 12 months longer than did the U.S. children in the equivalent grade. This difference in time is caused by the early start of school in New Zealand—New Zealand children start school at five years of age—and by the start of the school year in January. The school year starts in late January and continues for 37 weeks for the early grades and 34 weeks for the senior grades.

The average achievement numbers from the TIMSS disturbed the New Zealand government at the time, which had touted a "knowledge economy," defined as a market-driven educational policy in which education is seen as a commodity, and market competition decides which knowledge becomes available to the customer. Science, mathematics, and technology skills underpinned the projected economic growth for the future. With the election of a Labour government in 1999, the policy changed to "knowledge society," a term that implies softening of the economic focus to a more inclusive policy. This idea is expressed in an election paper printed at the time that states: "Education will be aimed at developing in all New Zealanders the ability to think for themselves, to acquire knowledge and learn new skills throughout their lives. Excellence for all—combining a broad general education with specialist study—must be the goal" (New Zealand Labour Party, 1999, 2).

Those concerned about New Zealand school children attaining only "average" achievement on the TIMSS often decry the inability of the New Zealand school system to produce expert scientists of international standing, rather than consider whether the results reflect a lack of science literacy in the population. On the surface, mean achievement scores on the TIMSS seem to indicate that New Zealand children do well with regard to science literacy (Figure 2). This is misleading, however. In New Zealand the school population in the final year (year 13) does not include many Maori, South Pacific peoples, or other disadvantaged population groups that tend to leave the school system well before year 13. These individuals lack functional science literacy and are excluded from career options requiring scientific backgrounds (Walker and Chamberlain, 1999).

The lack of science literacy in certain populations is contrary to the stated goals of the present New Zealand government and results in a citizenry that cannot make informed decisions about technology, health, and policy issues affecting their everyday lives. To accentuate the deprivation of these groups, primary school teachers in

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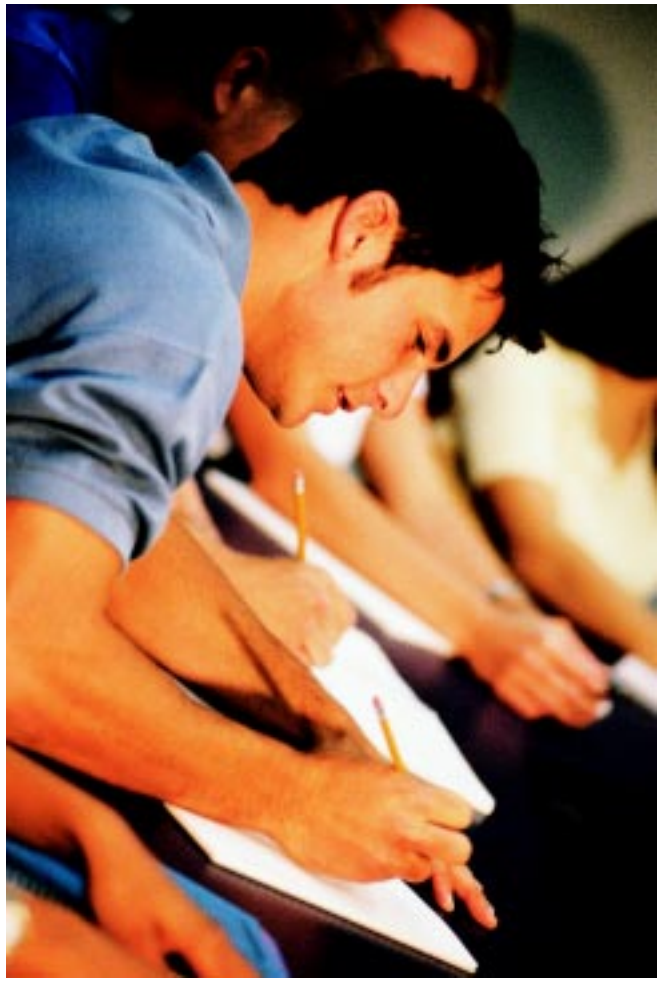

New Zealand are also often recruited from groups with low mathematics and science skills. While there is no shortage of candidates or trainees for the primary teaching levels in New Zealand, there is a problem with recruiting teachers with the right qualifications, particularly from underrepresented groups and those of working class backgrounds. The perceived low status of the profession and the relatively poor pay often drives more qualified people into other career choices. This perpetuates a cycle of poor science achievement overall, and expert scientists, who already tend to represent a very narrow cultural and ethnic group, become an even scarcer commodity (O'Neill, 1997; Hoff, 1999).

By extolling expertise over literacy, the ERO report may result in the implementation of policies that accentuate the spiral of poor recruitment to and negativism surrounding the sciences, such as placing science concepts in western, male constructs, which may be seen as irrelevant to working class children and those of ethnic minorities. By emphasizing achievement in narrow fields, it is too easy to lose sight of how science relates to the child's experience.

Of the four countries that the ERO team visited, only the Netherlands participated in the TIMSS science literacy survey. Although students in the last year of schooling in that country also scored highly in this survey, that was not the basis for their selection for comparison with the New Zealand system. The ERO survey specifically chose nations on the basis of their science and math achievement in the early and middle years of schooling. The ERO report does not investigate science literacy in the senior years at all. The Netherlands scored highly in all cohorts surveyed. New Zealand scored average in the early and middle cohorts, but above average in the senior literacy survey. The United States achieved above the international average on specific science tasks for the two early and middle year cohorts, but scored poorly in terms of science literacy.

Serving two masters

In a world where technological development is pervasive, any trend that discourages students from choosing against science as a career option has enormous implications. Science teachers often seem to serve two masters: the drive for producing science specialists and the drive for general science education. Whoever controls the funding sets the agenda. And unfortunately, success in science is often determined only by the accolades attached to the end product: It is easier to pin a medal on a high-achieving student than it is to measure the increase in general scientific literacy.

But instead of being frustrated by this system, educators should instead think of the process as a continuum: general education comes before specialization. Specialists without broad general knowledge have blinders on. They see only their specialty and not the connections that may be made to other branches of science. A scientifically illiterate population will not produce science candidates and cannot make use of the knowledge gained in scientific discoveries. Too much energy is used to debate and justify nonissues: Scientific literacy comes before, not instead of, specialization.

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