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## Formula for Success According to TIMSS or the Subliminal Decay of Jurisdictional Educultural Integrity?

*The results of international testing such as those found in the Third International Mathematics and Science Study (TIMSS) are often used to develop curriculum policy in a jurisdiction without questioning the significance of the scores and without realizing the connotative influences contained in these tests. This article compares the teaching practices of science teachers in Ontario, a modest-scoring jurisdiction, with the teaching practices of teachers in Alberta and Singapore, both high-scoring jurisdictions. An implicit "formula for success" for scoring high in TIMSS is identified. However, the main message of the article is that when developing curriculum policy, jurisdictions should instead first consider the desired local image of the educated person rather than allowing international test results to redefine an educational system that may be dysfunctional in the long term. The subliminal decay of jurisdictional educultural integrity may be a by-product of using international test results to determine local curricular policy.*

*Les résultats d'épreuves internationales telles que celles qui constituent la Troisième étude internationale de mathématiques et des sciences (TIMSS) servent souvent comme base dans le développement de matériel pédagogique pour un district donné sans que l'on s'interroge sur la signification des notes et sans que l'on dévoile les influences associatives évoquées par les épreuves. Dans cet article, l'auteur compare les stratégies pédagogiques d'enseignants de sciences en Ontario, une région qui donne des résultats moyens, à celles d'enseignants en Alberta et au Singapour, deux régions qui fournissent des résultats élevés. L'auteur identifie une "formule pour réussir" la TIMSS qui est implicite. Toutefois, le but principal de l'article est de recommander aux districts de considérer l'image locale que la population se fait d'une personne instruite plutôt que de redéfinir leur système pédagogique en fonction des résultats obtenus à une épreuve internationale. À long terme, des politiques didactiques locales basées sur des critères de comparaison internationale pourrait devenir disfonctionnelles et mener à l'affaiblissement de l'intégrité éducationnelle et culturelle du district.*

### Introduction

There is no shortage of information available with regard to the results of the Third International Mathematics and Science Study (TIMSS) or on international testing in general. This is not an article about the limitations of testing or comparison of student achievement results of various countries representing different cultures and lifestyles. What is distinct about this article is that it focuses on teacher practices in regard to teaching science rather than on science content. A set of factors involving teaching practices that, if followed, would probably result in high scores is identified. However, the substantive assertion is made that teaching practices are always embedded in an *educultural* context,

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making international or even interprovincial comparisons of test scores suspect. How do these tests results affect the integrity of the culture of education of a jurisdiction? What significance should be assigned to international scores such as those derived through TIMSS?

*Description of TIMSS and the Teacher Questionnaire*

Forty-five countries participated in TIMSS, which was conducted in the latter part of 1994 and early 1995 (Martin & Kelly, 1996). TIMSS was really a set of studies, that is, there were separate studies for students in grades 3 and 4 (population 1), grades 7 and 8 (population 2), and students in their last year of secondary school (population 3). These tests mainly employed multiple-choice, short-answer, and free-response questions. Other tests were also conducted using performance assessment. All these tests involved both mathematics and science. This article addresses population 2 results (as these were the first published) for science achievement. Although all but one province participated in the population 2 study, only five provinces oversampled to meet the minimum requirement to be reported as a separate jurisdiction: British Columbia, Alberta, Ontario, New Brunswick, and Newfoundland (Robitaille, Taylor, & Orpwood, 1996).

Much has been written about the limitations of making comparisons of countries based on international test results (Atkin & Black, 1997; Baker, 1997; Berliner, 1993; Biddle, 1997; Nagy, 1996). Certainly we should not dismiss these concerns, many of which have been previously identified by Nagy (1996): (a) the difficulties in test construction and design; (b) the content—in particular, the difficulties equating the intended curriculum for each jurisdiction (Bracey, 1998b) as well as the validity of the items (Wang, 1998); (c) difficulties with representative samples (Bracey, 1998b); (d) difficulties in determining the implemented curriculum and the attained curriculum; (e) different social conditions; (f) language problems; (g) enrollment patterns; (h) students working part-time; (Bracey (1998b) reports that the United States and Canada have by far the highest proportions of students who work more than three hours per day); (i) sampling and participation rates; (j) test and score accuracy; (k) funding problems; (l) rates of poverty in participating countries; (m) the practice of the media, governments, and the general public to interpret complex issues in a simplistic manner; and (n) whether or not international tests are deliberately used by various factions (including government) against public schools for various reasons (Berliner, 1993)—such as the wish to privatize public schools.

The focus of this study on teaching practices reported in TIMSS is unique. How different are teaching practices (as reported by teachers) between jurisdictions? Are comparisons of international test results valid when the philosophies of teaching and learning and ultimately the educultural contexts are so different? At the same time as data were compiled for student achievement in TIMSS, science teachers also completed a teacher questionnaire (International Association for the Evaluation of Educational Achievement, 1994) that asked questions about their academic and professional backgrounds, instructional practices, and attitudes toward teaching science. The questions that involved instructional practices and attitudes toward teaching science were asked in regard to the science classes that were also tested in TIMSS. Responses for key

Table 1  
Comparison of Teaching Practices for Science: Singapore, Alberta, and Ontario

|   | <i>Singapore</i>   | <i>Alberta</i>  | <i>Ontario</i>   |
|---|--|---|--|
| 1. Amount of class time students involved in science per week | mean 205 minutes grade 7<br>mean 208 minutes grade 8           | mean 220 minutes grade 7<br>mean 211 minutes grade 8            | mean 133 minutes grade 7<br>mean 168 minutes grade 8             |
| 2. Teacher influence choosing subject matter to be taught     | 19% had a lot of influence g7<br>17% had a lot of influence g8 | 10% had a lot of influence g7<br>13% had a lot of influence g8  | 32% had a lot of influence g8<br>31% had a lot of influence g8   |
| 3. Teachers choosing textbooks                                | 49% had no influence g7<br>58% had no influence g8             | 9% had a lot of influence g7<br>13% had a lot of influence g8   | 32% had a lot of influence g7<br>35% had a lot of influence g8   |
| 4. Teacher teaching to the whole class                        | 54% most lessons g7<br>45% most lessons g8                     | 43% most lessons g7<br>38% most lessons g8                      | 25% most lessons g7<br>18% most lessons g8                       |
| 5. Teacher assigning homework per week                        | 66% assign homework 1-2x's g7<br>77% assign homework 1-2x's g8 | 71% assign homework 1-2x's g7<br>31% assign homework over3x'sg8 | 42% assign homework 1-2x's g7<br>7% assign homework over 3x's g8 |
| 6. Teacher assessment:  | (a) 61% use a lot g7   | (a) 83% use a lot g7  | (a) 26% use a lot g7   |
| (a) multiple-choice tests                                     | 52% use a lot g8   | 68% use a lot g8  | 39% use a lot g8   |
| (b) observations of students                                  | (b) 35% use a lot g7   | (b) 29% use a lot g7  | (b) 61% use a lot g7   |
| (c) student responses.  | 43% use a lot g8   | 21% use a lot g8  | 48% use a lot g8   |
|   | (c) 31% use a lot g7   | (c) 12% use a lot g7  | (c) 49% use a lot g7   |
|   | 37% use a lot g8   | 12% use a lot g8  | 46% use a lot g8   |

(Puk, 1997, 1998).

items from the teacher questionnaire are summarized in Table 1. These responses indicate beguiling differences between the teaching practices of Ontario teachers and teachers in Singapore and Alberta. It should be noted that teacher data recorded by TIMSS reflect teacher self-reports.

In order to provide some base reference point when making the comparisons between teaching practices, Table 2 is included to provide overall student achievement results for the jurisdictions included in this article and others for interest's sake. Nagy (1996) cautions that determining levels of error for international tests is a complex task and that levels of error are underestimated and the claimed level of accuracy is an overestimate. Nagy suggests that the complexity of the required negotiations to determine test items precludes the use of a standard sampling pattern. "Consequently, many scores close to each other should be considered 'tied'" (p. 405).

This article explores the teacher questionnaire results for grades 7 and 8 for the jurisdictions of Ontario, Alberta, and Singapore. Singapore is included because it was the highest-scoring jurisdiction in both grades 7 and 8 and as such is often included in comparisons provided through the media (e.g., Education Quality and Accountability Office, 1998; Ontario Ministry of Education and Training, November, 1996; Science Teachers Association of Ontario, 1997) and because the reported teaching practices of Singapore and Alberta were similar. Alberta was not only the top-scoring Canadian province but also close to the top internationally. Ontario is included because it has the largest provincial population, had the largest sampled population in TIMSS, and scored the lowest of the participating provinces.

*Teacher Questionnaire Responses*

A conclusion based on the results of the teaching practices questionnaire (see Table 1) might be that there are a number of actions that jurisdictions could take to ensure that their students score high in international tests such as TIMSS. A

Table 2  
Student Performance in Science

|                       | Average Percent Correct<br>Grade 7 | Science Overall<br>Grade 8 |
|-----------------------|------------------------------------|----------------------------|
| Singapore             | 61                                 | 70                         |
| Korea                 | 61                                 | 66                         |
| Alberta               | 60                                 | 65                         |
| Japan                 | 59                                 | 65                         |
| Canada                | 54                                 | 59                         |
| Newfoundland          | 53                                 | 59                         |
| Germany*              | 53                                 | 58                         |
| United States         | 54                                 | 58                         |
| New Brunswick         | 51                                 | 57                         |
| Ontario               | 52                                 | 56                         |
| International Average | 50                                 | 56                         |

Beaton et al. (1996); Robitaille, Taylor, & Orpwood (1996).

\*Germany did not meet age/grade specifications.

“simple formula for success” could include the following: (a) a mandatory number of hours for subject matter; (b) development and control of detailed provincial curriculum guidelines by a central government agency that teachers must follow; (c) directives by the government agency as to which textbooks teachers should use and that teachers should use textbooks on a regular basis; (d) requirements that teachers give homework regularly during the week; (e) requirements that teachers use the lecture style of instruction most of the time; and (f) insistence that teachers use multiple-choice testing most of the time to determine student achievement.

Both Alberta and Singapore appear to use aspects of this formula, and certainly there are benefits for doing so depending on one’s perspective. In both Alberta and Singapore, students spend much more time studying science than do Ontario students. Teachers in both of these jurisdictions reported they had considerably less influence in determining the subject matter they taught than Ontario teachers. Not only are textbooks dictated by the central government, but they are used much more often. In addition, homework is given much more often in these two jurisdictions (see Table 1).

More important, the direct instruction style of teaching and multiple-choice testing appear to be used considerably more often than in Ontario schools (Puk, 1998). Teachers in Singapore and Alberta “work with a class with the teacher teaching the whole class most lessons” more often than Ontario teachers do. For example, in grade 7, 54% of teachers in Singapore and 43% of teachers in Alberta teach most of their lessons in this manner, compared with 34% in Ontario (TIMSS International Study Center, 1996a, 1996b). At the grade 8 level, 45% of Singapore teachers and 38% in Alberta organize their classes in this manner most of the time, whereas only 18% of Ontario classes employ this style most of the time (TIMSS International Study Center, 1996a, 1996b).

Teachers from Singapore and Alberta seem to place more emphasis on multiple-choice/true-false/matching tests than do teachers from Ontario. At the grade 7 level, 61% of teachers from Singapore and 83% from Alberta said they weight this type of testing “quite a lot” in their student assessment procedures, whereas only 26% of Ontario teachers do the same. At the grade 8 level, 52% of teachers from Singapore and 68% from Alberta use this type of assessment “quite a lot” in their student assessment procedures, whereas 39% of Ontario teachers do the same (TIMSS International Study Center, 1996a, 1996b). It is also important to note that 75% of the TIMSS questions involved multiple-choice questions (Beaton et al., 1996). Therefore, a logical assumption is that students who are familiar with multiple-choice questions in their regular ongoing classroom work would do better on an international test that features multiple-choice questions.

#### *What Are the Implications for Science Education in Ontario Specifically and International Testing Generally?*

A question that seems noticeably absent from most discussions in regard to international test results must be asked. What is the distinction of a jurisdiction being able to say that it scored high in TIMSS? One simple conclusion from the TIMSS results is that if jurisdictions wish to score high in TIMSS, they should adopt teaching practices that are similar to those of higher-scoring jurisdictions

such as Alberta and Singapore. However, is there a correlation between high scores and standard of living? Will it improve the gross national product? Are citizens in high-scoring jurisdictions healthier or happier? Are these countries more democratic? Will high scores attract investment or tourism? Do high scores mean a higher minimum wage? Some jurisdictions suggest that these tests measure the knowledge required to function effectively in society. As Bracey (1998a) points out, one should first ask for a definition of "function effectively in society" and then "ask someone to tell you how the department [US Department of Education] knows that the TIMSS math and science tests measure this ability" (p. 686).

The answer to most of these questions is that there is little substantive evidence of the significance of high scores for any jurisdictions. There are no longitudinal studies to determine the social benefits of high scores. The assumption is simply that it must be a good thing for a jurisdiction to score high. However, at this time it would appear that high scores simply mean bragging rights about something of unclear significance. The US is considered to be the most powerful nation in the world, with most currencies being compared with the strong showing of the US dollar. The national US achievement scores in science were almost the same as the scores for Canada and just slightly better than those of Ontario. Both Ontario and US scores were considerably lower than those of Singapore, but, more important, lower than approximately 25 other jurisdictions (it should be pointed out that some of these other jurisdictions did not meet all of the sampling requirements [Beaton et al., 1996]). Calls for "pursuing world-class standards" and the "pursuit of excellence" (Hawkes, Kimmelman, & Kroeze, 1997) are often made by business and industry and are expressed in conjunction with the desire to score high on international tests; but again, seldom are the long-term benefits articulated as to why a jurisdiction should score high. According to Atkin and Black (1997), some reasons that countries gave (as part of a study conducted by the Organization for Economic Cooperation and Development [OECD]) for wanting to reform their school curriculum involved the perceived decline in national economies and international trade. These countries "wanted to increase productivity and believed that the improvement of science, mathematics, and technology education was central" (p. 23). However, the relationship between an increase in productivity (assuming for the moment this should be a defining criterion for identifying school curricula) and high scores on international tests is dystopian and unproven. Even the usual implicit assumption that higher scores mean high levels of understanding of science and that this will be translated into a highly trained work force has come under recent criticism. Smith (1999b) has raised the issue that many Euro-American companies have moved their operations to other countries, the implication being that there may not be the jobs available in Canada to benefit these scientifically literate, virtual employees.

Nonetheless, many jurisdictions have revamped the science curriculum in elementary and secondary schools at least in part because of the influence of international tests such as TIMSS. In Illinois, for example, the First in the World Consortium along with federal support from the US Department of Education developed a mandate for excellence in mathematics and science by "benchmarking the performance of schools in the consortium to the interna-

tional measure used by the Third International Mathematics and Science Study (TIMSS)" (Hawkes, Kimmelman, & Kroeze, 1997, p. 31).

Ontario has similarly been influenced by TIMSS. In a news release (Ontario Ministry of Education and Training, November 1996) soon after the TIMSS results became public, the Minister of Education and Training stated that the results of TIMSS placed Ontario student achievement behind that of Alberta, Singapore, and other jurisdictions. The Minister went on to say "it's time to move our students to the head of the class, where they belong ... with a lot of hard work, it can be done, and we have a plan in place to ensure it happens" (p. 1). TIMSS appears to have had a Sputnik-like influence on the Ontario government's desire to compete with higher-scoring jurisdictions. In another news release (Ontario Ministry of Education and Training, June 1997), the same Minister, in reference to the newly released elementary curriculum, again emphasized the need for Ontario students to "keep pace with their counterparts in other countries and other provinces" (p. 1). In March 1998 a new Minister of Education and Training, referring to the newly released *Science and Technology: The Ontario Curriculum, Grades 1-8*. (Ontario Ministry of Education and Training, 1998b) once more expressed the Ontario government's perspective that "Ontario students have not fared as well as other students in national and international tests of science" (Ontario Ministry of Education and Training, March 1998a, p. 2). In the latest development, the Premier of Ontario has unveiled a new "Charter of Education Rights and Responsibilities," which contains among other things plans to conduct province-wide testing *every year in every grade in core subjects* (including science and mathematics, Philp, 1999).

Other indications that TIMSS has had an influence on the Ontario curriculum can be found in the new provincial curriculum guidelines. The content areas of life science, earth science, physics, and chemistry tested in TIMSS match well with the content areas of the new Ontario elementary science guidelines (Ontario Ministry of Education and Training, 1998b): life systems, earth and space systems, matter (chemistry and physics), and energy (physics). The only other content area tested in TIMSS, environment and the nature of science, is covered in each grade of the new guidelines under the heading "Relating Science and Technology to the World Outside the School." Numerous, specific expectations for students at each grade level in each of the content areas are provided in this guideline. As the Minister of Education and Training stated (Ontario Ministry of Education and Training, March 1998a), "Today, I am releasing Ontario's first completely new science curriculum in 30 years" (p. 2). In the new secondary curriculum (Ontario Ministry of Education and Training, 1999) the number of compulsory credits in mathematics and science has been increased over the previous requirements.

One of the most disconcerting aspects of this uncritical quest for high scores is that some countries such as Japan and Germany that are perceived to have done well in TIMSS are attempting to change their current educational systems. These changes "are profound in their conception of a desirable education and radical in their departure from past practice" (Atkin & Black, 1997, p. 23). As Ontario adopts the "formula for success," as it aspires to be more like the top-scoring jurisdictions, the agenda will have changed. Obviously, if these other countries change their educational systems substantially, the test ques-

tions for future international tests will also change (given that TIMSS test questions are based in part on the intended curriculum employed in each participating jurisdiction), just when Ontario (or other jurisdictions) may have revamped its intended curriculum and teaching practices to look more like those of other high-scoring jurisdictions.

Just as there is no magic bullet for improving an education system, so there is no clear path to be found by trying to imitate "successful" neighbours. There is no substitute for hard argument to formulate the standards of quality that each country values and to work out the policies that can help achieve those standards. The TIMSS data can provide no more than a few clues. (Atkin & Black, 1997, p. 28)

Perhaps there are alternative approaches to curriculum reform other than this indiscriminate follow-the-leader type of behavior.

As stated above, the prevailing method of assessing achievement in TIMSS is that of multiple choice—in fact approximately 75% of the test was in the form of multiple-choice questions. Teachers from both Alberta and Singapore indicate that they place more emphasis on this type of assessment than do Ontario teachers. These types of questions usually assess lower-order skills such as knowledge and comprehension and do not usually assess critical thinking skills such as synthesis. However, they certainly do not assess the skills of inquiry as a constructivist process, that is, a set of skills used by the learner in a self-directed manner to interact with his or her environment in order to derive meaning (Puk, 1996b).

A traditional pedagogy (as exemplified by the "formula for success" observed above) implies that teachers stress memorization of facts and propositions. However, does this approach limit students' ability to think for themselves and transfer skills beyond the classroom? More specifically, what is the long-term significance of knowing or not knowing what is formed when a neutral atom loses an electron (a question from the science test, Beaton et al., 1996) or how many legs and body parts all insects have? What should be of at least equal value in terms of the goals of education is what students can do with that acquired knowledge. The emphasis in science education should be placed on the recursive relationship between process and product.

Are there alternative approaches to curriculum reform that break away from the homogenizing behavior noted above? Has Ontario been a leader in any aspects of education? Have all the efforts that have been spent on educational research in Ontario to date not resulted in any innovative developments? Does Ontario not have an educulture of its own? This article, rather than just comparing test results between countries or even provinces on the basis of content, examines teaching practices. Rather than comparing jurisdictions with each other, let us now compare the espoused and de facto teaching practices (Puk, 1994) in Ontario. How does Ontario measure up with itself? What do educators say they value in terms of teaching practices (their espoused level of aspiration) compared with what is actually done in the classroom (the de facto level of aspiration)?

Rather than reacting to international test results and realigning the curriculum to correspond with these tests, we should examine why we do what we

do. Perhaps the starting point for resolving the current simplistic manner in which educational reform occurs begins with an image of the valued human qualities a jurisdiction expects in the educated person. An overriding goal of education in Ontario for several decades (at least the espoused goal), as first described in the "image of the learner" (Ontario Ministry of Education, 1980) has been the education of the learner as a "self-directed, self-motivated problem-solver" (p. 2) engaged in "inquiry" (p. 3). "The concept of the learner as a mere processor of information" (p. 2) was replaced by what later came to be known as a "constructivist" style of teaching and learning. It is important to note that one of two areas where Ontario teachers believed they were more prepared to teach science topics than teachers from Singapore was that of "organizing, representing and interpreting data, making conclusions," in other words, teaching the process of managing one's own learning (Puk, 1997).

Ontario has a long tradition of featuring inquiry in its mandated curriculum (Puk, 1994; Ross & Maynes, 1985). Inquiry, a set of skills or a process for deriving meaning by interacting with one's environment in a self-directed manner, has been described and mandated in Ontario provincial guidelines since at least the middle 1970s (Puk & Haines, 1998). However, it is difficult to measure student performance in regard to an inquiry approach to teaching and learning through multiple-choice, short-answer, and even through extended-response as defined by TIMSS. In order to assess student ability in regard to inquiry, students would need to demonstrate how to develop their own question (given a scenario), be able to develop a plan or framework, know the kind of framework that corresponds to the type of question asked, be able to obtain information not already known by the student in order to complete the framework, and make conclusions (Puk, 1996a). Inquiry of this type involves being able to interact with complex, messy problems and whole topics rather than bits and pieces of decontextualized, bare facts. It involves constructing meaning through social interaction, using multiple resources rather than one centrally assigned textbook. Even in the performance assessment component of TIMSS (this component is a separate study in which few jurisdictions participated, International Association for the Evaluation of Educational Achievement, 1997) students are usually answering a preset question and filling in someone else's framework in an abstract manner (i.e., without interacting with resource materials or with other people).

According to the results of the teacher questionnaire, the predominant style of teaching that both Alberta and Singapore employ is that of the teacher teaching to the whole class for "most of the time" (see Table 1). At the grade 8 level, only 18% of Ontario teachers said they used this method of teaching "most of the time." This style might be classified as a transmission or lecture style of teaching and learning (Miller & Seller, 1990; Smith, 1999a) where the teacher directs and the students listen. What this study has confirmed is that students who receive the lecture style of teaching, which is associated with rote learning and multiple-choice evaluation in the classroom, do well in TIMSS, a predominantly "regurgitating the facts" style of assessment. Ontario teachers use "observation of students" and "student responses" much more in their classroom assessment of students than teachers in Singapore and Alberta (see Table 1). It is not surprising that a direct instruction methodology would be

used in jurisdictions that have large class sizes such as Korea and Japan (TIMSS International Study Center, 1996a). In large classes the lecture style is an efficient teaching-learning strategy that facilitates rote learning. However, inquiry does not involve rote learning. Inquiry involves self-directed exploration into the unknown (at least to the student). If the lecture style of teaching were to be employed as the predominant style of teaching and learning in Ontario, education would revert to the style that was more common in classrooms before and during the 1970s. This should be considered a regressive development and contrary to Ontario's mandated educultural approach to teaching and learning (Puk & Haines, 1998). In Ontario a variety of teaching-learning strategies are encouraged.

If Ontario education values inquiry as an important lifelong skill, and certainly the historical literature would suggest that this is the case (Puk & Haines, 1998), then it may be more important for Ontario to determine how well and how extensively inquiry is being taught and develop appropriate assessment to coincide with this approach to teaching and learning. Most Ontario curriculum guidelines, including the newest elementary science guideline (Ontario Ministry of Education and Training, 1998b), continue to espouse extensively the concept of inquiry but provide scant description of what inquiry is, how teachers can successfully teach it in their classrooms, and how the skills of inquiry evolve from grade to grade.

A subtle distinction between the mandated curriculum versus the intended and implemented curricula must be made here. Ontario curriculum guidelines do feature (or at least use the word) inquiry, as do the science guidelines in Alberta (Alberta Ministry of Education, 1990). The problem is that international tests generally focus on content, not process, and they divert attention from *how* students are learning to *what* they are learning in terms of knowledge outcomes. As long as students know "the" answers and score high, attention is diverted from how they acquire this information. Inquiry, in Ontario at least, remains an inert mantra rather than a dynamic process. (Puk & Haines, in press, found that in a study involving a representative sample of 127 schools across Ontario, the vast majority of student teachers did not receive encouragement to teach inquiry, did not receive assistance to teach inquiry, did not observe their associates teaching inquiry, and did not hear any discussions in their respective schools about the teaching and learning of inquiry during a four week practicum.) Perhaps this empty mantra is a result of so much attention being directed toward creating the conditions to employ the formula for success found in the science portion of TIMSS.

Simple formulae are tempting. They represent the positivistic-mechanistic belief that simple solutions can be extracted from and applied to complex, chaotic environments such as educational systems. Such formulae are straightforward, tidy, and quantifiable.

To paraphrase Whitehead, a rigorous mechanistic paradigm for education has done more harm than good; it dehumanized education and it caused educators to fixate on a set of abstractions that were disastrous in their influence on modern education. The set of abstractions consists of the "psychologizations" of educational principles with the intention of generating quantifiable outcomes. (Hunter & Benson, 1997, p. 92)

More subtle, however, is the contribution simple formulas make toward the globalization and homogenization of education and the "One Civilization" (Winchester, 1999). Providing a globalized, standardized approach to education would result in the creation of employees that could fit into various job scenarios no matter where that job might be situated. As Smith (1999a) has forcefully argued, world bodies such as the World Bank, the Organization for Economic Cooperation and Development, and the Trilateral Commission have all demanded that "any viable education today must serve, as its primary responsibility, the needs of a new global free market economy" (p. 7). What is required to carry out this mandate is "a citizenry historically amnesiated to such a degree that no further questions will be asked regarding Education's ultimate purpose" (p. 7). The International Association for the Evaluation of Educational Achievement (the organization that created and managed TIMSS) may be the future educational equivalent of the World Bank.

Simple formulas, however, can be distracting. Reforming the curriculum in order to do well in international testing may divert attention and energies from the issue of jurisdictional educultural integrity, that is, the ability of a jurisdiction independently to determine and protect the unique set of values or "borders" that defines its educational culture and makes it unique. Kelsey (Smith, 1999b) suggests that the current, pervading international paradigm is that of "economic fundamentalism" (p. 94) whose purpose is the erosion of national identity in order to better serve the corporate agenda. Colorful jurisdictional educultures would be replaced by what Mander and Goldsmith refer to as a "*monoculture*—the global homogenization of culture, lifestyle, and level of technological immersion, with the corresponding dismantlement of local traditions and economies" (Smith, 1999b, p. 97). The borders of jurisdictional educultures would be opened and exposed in order to suit the corporate cause with interchangeable parts and interchangeable bodies.

More specifically, in Ontario, it may divert attention and energies from ensuring that an enduring espoused goal of education, that of implementing the teaching and learning of inquiry into all classrooms, is effectively actualized. Some studies have raised the issue that in fact, although inquiry is espoused as being a critical outcome of schooling, it has not been implemented successfully in Ontario schools (Ontario Ministry of Education, 1985, 1988; Puk, 1996b; Puk & Haines, 1998; Robinson, 1978). If the inquiry approach to teaching and learning had been taken seriously, educators would be more concerned about how well prepared students are to be able to do something meaningful with the "facts" that they acquire.

Bailey (1998) has suggested that the reason for the development of the Pan-Canadian Protocol—a large-scale science curriculum innovation that has influenced the development of science curriculum in the provinces and that has been directly influenced by TIMSS (Council of Ministers of Education, 1997; Ontario Ministry of Education and Training, March 1998a)—is linked to "the nation's relative place in the global economy" (p. 11) and that the "implied conception of scientific literacy [in the Protocol] is an instrumental one, designed to produce the (relatively uncritical but skilled) workers in the science and technology sector of tomorrow" (p. 2). It is time to put as much emphasis on teaching and assessing process as we have traditionally placed on teaching

and assessing content. Considering the time that has passed since Dewey advocated the use of inquiry as an approach to teaching and learning, he would not be impressed with a vision of education that would breed uncritical workers!

### Conclusions

Ontario might wish to improve its standing in science achievement in comparison with Alberta and other jurisdictions, but the reasons for doing so should be critically examined and clearly articulated. "Questions of national performance need to be contextualized in terms of social values, specific educational policies, and the structure of the educational systems being compared" (LeTendre, 1999, p. 42). The quest for higher international test scores should not be conducted at the expense of undermining a historic emphasis on critical thinking skills as exemplified by an inquiry approach to teaching and learning. Employees and citizens of the 21st century may need to have scientific knowledge, but they will also certainly require the ability to solve problems, both in their work and in their private lives. If the amount of class time devoted to learning science is increased in Ontario in grades 7 and 8, more time should be spent on both learning scientific knowledge and acquiring the skills of inquiry. Both are important. Also, more effort needs to be directed toward devising assessment strategies that will provide feedback of student performance with regard to their use of inquiry and to teaching practices in regard to teaching inquiry. TIMSS scores may be viewed as one source of assessment information but should not be the primary source. The profound limitations of international test results should render great caution to educational reform, particularly when the educultural integrity of participating jurisdictions may be at risk.

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