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# Aboriginal Students' Achievement in Science Education: The Effect of Teaching Methods

*Some authors assume that the academic difficulties encountered by Aboriginal students can be partly explained by the discrepancy between teaching methods and Aboriginal learning styles. However, this hypothesis lacks empirical foundations. Using pan-Canadian data, we tried to identify the most efficient teaching methods for Aboriginal students and assessed whether these methods were associated with performance differences between Aboriginals and non-Aboriginals in science education. Results revealed that judicious dosage and a proper balance among teaching methods seem to be required for students' optimal achievement. In addition, only marginal differences were observed between Aboriginals and non-Aboriginals. However, standard assessment methods might partly explain these unexpected results.*

*Certains auteurs tiennent pour acquis que les difficultés académiques auxquelles se heurtent les étudiants autochtones s'expliquent en partie par la divergence entre les méthodes d'enseignement et les styles d'apprentissage chez les Autochtones. Toutefois, cette hypothèse manque de fondements empiriques. Puisant dans des données qui couvrent tout le Canada, nous avons tenté d'identifier les méthodes d'enseignement les plus efficaces auprès des étudiants autochtones pour ensuite évaluer dans quelle mesure ces méthodes étaient liées à des écarts de rendement en sciences entre les Autochtones et les non Autochtones. Les résultats indiquent qu'un rendement optimal de la part des étudiants semble dépendre d'une dose judicieuse et d'un équilibre bien réussi entre les méthodes d'enseignement. De plus, seules des différences marginales ont été notées entre les Autochtones et les non Autochtones. Par contre, des méthodes normalisées d'évaluation pourraient expliquer en partie ces résultats inattendus.*

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## *Introduction*

### *Learning Styles*

Learning styles constitute a major research branch in Aboriginal education both in the United States (American Indian Society for Engineering and Sciences, 1994; Chavers, 2000; Wilcox, 1996) and Canada (MacIvor, 1995). Learning styles were defined by Hodgson-Smith (2000) as "an individual's characteristic strategies of acquiring knowledge, skills, and understanding" (p. 159). A learning style would in fact refer to a superordinate construct (Shade, 1997) that would explain a set of differences in processing information (Hale, 2002). It is generally accepted that "the approach to learning and the demonstration of what one has learned is influenced by the values, norms, and socialization practices of the culture in which the individual has been enculturated" (Swisher & Deyhle, 1989, p. 2). Consequently, some authors (Deyhle & Swisher, 1997; St. Charles & Costantino, 2000) contend that learning styles may vary across cultures.

According to some authors, Aboriginal students could be generalized as being right-brain-oriented (Goin, 1999), cooperative (Fraser, 1996; Pewewardy & Hammer, 2003), non-verbal (Cajete, 1999a, 1999b), holistic (Moore, 1994; Robinson-Zanartu, 1996), kinesthetic (Smith & Shade, 1997; Wilson, 1997), experiential (Jacobs & Reyhner, 2002; Preston, 1991), visual (Peacock & Cleary, 1997), inductive (Pepper & Henry, 1986), and reflective learners (Pewewardy, 2002). They might also be more field-dependent (Friesen & Friesen, 2002) and inclined to learn by observation and imitation (Hipps, 1999; Nelson-Barber & Estrin, 1995). Along the same lines, Stairs (1991) reports that Inuit make a distinction between the transmission of knowledge by observation and imitation of daily family and community activities (*Isumaqsayuq*), and teaching that involves a high level of abstraction and verbalization with the sole objective being to fill a specialized position (*Ilisayuq*). According to Hadfield, Martin, and Wooden (1992), the learning style favored by students would have a significant effect on academic achievement: for example, the capacity to categorize and sequence information, as well as the ability to visualize objects in space, would make learning mathematics easier.

There has been recent interest in identifying the learning styles particular to Aboriginal students, because this task currently remains challenging for teachers (Brislin & Horvath, 1997). It is believed that a greater correspondence between their teaching style and the students' learning style would ensure better academic results (Brown, 2003; Pewewardy, 1998). However, the studies analyzed by Irvine and York (1995) clearly indicate that the veracity of this largely held assumption should be examined more closely.

Most studies that address the gap between teaching methods and the specific learning style of Aboriginals rest predominantly on anecdotal testimonies rather than on empirical data (McCarty, Wallace, Lynch, & Benally, 1991; McDowell Group, 2001). As for the few empirical studies that do exist, Irvine and York (1995) note their many methodological flaws, including poor instrumentation that often confuses *learning styles* and *skills*. In addition, the links between measure and theory are at times weak, and when evaluated, the instruments' metric qualities are generally unsatisfactory. Moreover, the predictive validity of these tools has yet to be demonstrated (Irvine & York).

These observations highlight the risks associated with research on learning styles. First, the uniform attribution of a learning style to all Aboriginal students threatens to propagate a biased stereotype of the Aboriginal student. Second, there is a risk of lowering expectations toward Aboriginal students once this representation is integrated by their teachers.

One way to avert these risks while pursuing the same goal is to approach the problem by investigating whether teaching methods yield a differential response across cultures supposedly characterized by diverse learning styles. Indeed, the identification of efficient practices avoids the construction of a stereotyped portrait of Aboriginal students and can help develop strategies applicable in the classroom. In addition, assessing teaching methods is easier than categorizing and measuring learning styles.

*Teaching Styles*

According to Hoyt and Lee (2002), it is possible to divide teacher intervention into three hierarchical levels: teaching *methods* indicate specific teaching techniques, whereas teaching *approaches* encompass a number of teaching methods related by the similarity of their goals and the underlying conception of the learner. Finally, teaching *styles* would indicate how a teacher combines various teaching approaches. The choice of teaching methods would, therefore, reflect the teachers' beliefs regarding the learner's role in the learning process (Brown, 2003).

Numerous authors identify teaching methods that are supposed to optimize Aboriginal student achievement. In these proposed methods, the use of lecture-style teaching and competitive approaches are discouraged (Prater et al., 1995), and teachers are encouraged to use field trips (Cajete, 1999b), project-based approaches (Wilson, 1997), storytelling (Gilliland, 1999; Snively, 1990), and peer-learning (Wilson, 1997). However, here again we find a lack of rigorous empirical studies, which is indeed noted by Irvine and York (1995), who caution that "it is premature to conclude that any one method of teaching is effective with a particular cultural group" (p. 493).

*Aboriginal Students and Science Education*

The emphasis placed on learning and teaching styles in Aboriginal schools stems from concerns about the quality of teaching. In the United States, particular attention is given to science education, which according to many should be redefined to better foster success among Aboriginals (Davison & Miller, 1998; Nelson-Barber & Estrin, 1995), because they are still underrepresented in professions that require further education in sciences and mathematics (Nelson-Barber & Estrin). Similar preoccupations were voiced in Canada by the Auditor General (Fraser, 2004), especially about the educational gap between Aboriginal and non-Aboriginal populations. Aikenhead and Huntley (1999) also acknowledge that science education poses particular academic and cultural challenges to Aboriginal students.

*Research Hypotheses*

This study put two research hypotheses to the test in the empirical logic described by Popper (1959): (a) no specific teaching method is particularly effective in leading to achievement in Aboriginal students, and (b) no difference between Aboriginal and non-Aboriginal students exists regarding the

effectiveness of teaching methods. In this article we refute both hypotheses in an attempt to put their congruence with reality to the test. The thesis of the lack of fit between teaching methods and learning styles will be supported only if our results lead to refutation of both hypotheses through uncovering statistically significant and pragmatically considerable effects.

## *Method*

This research follows a nonexperimental design (Johnson & Christensen, 2004), and the data come from the Science III 2004 Assessment of the School Achievement Indicators Program (SAIP). This pan-Canadian program, for which the Council of Ministers of Education, Canada (CMEC) is responsible, has been ensuring the cyclical assessment of Canadian students' achievement in mathematics, reading, writing, and science education since 1993. The most recent assessment in science education was done in the spring of 2004 on a random sample of approximately 25,000 students from 2,500 public schools throughout Canada (CMEC, 2006). This means, though, that Aboriginal students enrolled in band-operated schools are not represented.

### *Sample*

The database used for the present study includes 25,730 respondents, of whom 1,104 were categorized as Aboriginal. Aboriginal membership was determined by the use of an Aboriginal language at home or at school and by birth in Canada. Although we are aware that this method of identification excludes Aboriginal students who do not speak their vernacular language, these variables are the only ones available that supply potential information on ethnocultural origin. A high number of participants (9,906 or 38.5%) failed to answer one of these three questions, which left us with a sample of 15,825 students, of whom 1,104 (7.0%) are categorized as Aboriginal and 14,720 (93.0%) as non-Aboriginal. The sample was weighted to level out the groups for comparisons.

Of these 15,825 respondents, 8,456 (53.4%) are 13 years old and 7,368 (46.6%) are 16 years old (Table 1). The sample is composed of 8,236 girls (52.0%) and 7,588 boys (48.0%). The distribution of students according to age ($\chi^2$ [1]=4.019, $p$=0.045; $\varphi$=0.016) and gender ($\chi^2$ [1]=1.350, $p$=0.245; $\varphi$=0.009) differs only marginally (not significantly in the case of gender) between the two groups. Each province and territory is represented.

Table 1
Age and Sex of Respondents

| | | *Non-Aboriginal* | *Aboriginal* | *Total* |
|---|---|---|---|---|
| Age | 13 years | 7,834 (53.2%) | 622 (56.3%) | 8,456 (53.4%) |
| | 16 years | 6,886 (46.8%) | 482 (43.7%) | 7,368 (46.6%) |
| | Total | 14,720 | 1,104 | 15,824 |
| Sex | Girls | 7,680 (52.2%) | 556 (50.4%) | 8,236 (52.0%) |
| | Boys | 7,040 (47.8%) | 548 (49.6%) | 7,588 (48.0%) |
| | Total | 14,720 | 1,104 | 15,824 |

*Variables*

Sixteen teaching methods make up the independent variables—for example, "We participate in scientific projects"—to which the respondents indicated how frequently each occurred in their science education courses. A four-point, ordinal answer format was used: *rarely or never*, *a few times a month*, *a few times a week*, and *almost every day*.

The dependent variable is the result of a standardized science education exam administered as part of the SAIP. The test has 129 multiple-choice questions distributed across five levels of difficulty. The result for each item is rated (1) for success and (0) for failure. The dependent variable is the arithmetic mean of the results to each question.

*Limitations*

It is important to note that this study deals only with 13- and 16-year-old science education students and that science is a subject that presents particularities regarding pedagogical approaches (e.g., conducive to experiments). Next, it is essential to wonder whether control tests can be considered universally adequate to measure achievement. In order to offer a reliable measure of a student's skills, assessment must be coherent with the teaching methods advocated by the teacher. It follows that the test that had to measure the students' skills could have favored those who attended classrooms where teaching approaches were more traditional. Finally, keeping in mind that band-operated schools were not sampled, the variable defining ethno-cultural belonging rests solely on public school students' own declarations that they use an Aboriginal language. This being the case, no distinction may be made about the nation of belonging, the place of residence (on or off reserve), or the status (registered or not). In addition, Aboriginals who cannot use their vernacular language are de facto excluded from the Aboriginal subsample.

## *Results*

The test results vary between 0.0% and 94.0%. Non-aboriginals ($s$=0.119) scored 51.9% on average, whereas Aboriginals ($s$=0.119) scored an average of 46.3%. The grade distribution for both groups does not show any severe departure from the normal distribution, and the standard deviation is the same for both groups (Table 2), which allows us to use parametric tests. Table 3 indicates the frequency with which the teaching methods are used according to whether students belong to an Aboriginal group.

We also examined whether the teaching methods varied across groups. We used the likelihood ratio, which is less sensitive to the contingency table format than Pearson's test of independence (Howell, 2003). The effect size was es-

Table 2
Total Results (Descriptive Statistics)

| | *n* | *Mean* | *Median* | *s* | *Min.* | *Max.* | *Skewness* | *Kurtosis* |
|---|---|---|---|---|---|---|---|---|
| Non-Aboriginals | 14,720 | 0.519 | 0.520 | 0.119 | 0.00 | 0.94 | 0.011 | –0.292 |
| Aboriginals | 1,104 | 0.463 | 0.463 | 0.119 | 0.15 | 0.92 | 0.001 | –0.266 |
| Missing | 747 | 0.498 | 0.500 | 0.120 | 0.08 | 0.94 | –0.048 | –0.272 |
| Total | 16,571 | 0.509 | 0.506 | 0.120 | 0.00 | 0.94 | –0.015 | –0.267 |

Table 3
Frequency of Teaching Methods

| | | *Rarely or never* | *Few times a month* | *Few times a week* | *Almost every day* |
|---|---|---|---|---|---|
| Teacher writes notes | non-Aboriginals | 7.1% | 14.4% | 32.2% | 46.2% |
| | Aboriginals | 9.3% | 14.2% | 28.3% | 48.2% |
| | Total | 7.3% | 14.4% | 31.9% | 46.4% |
| Solve problems | non-Aboriginals | 4.1% | 12.5% | 39.9% | 43.5% |
| | Aboriginals | 6.8% | 11.4% | 38.0% | 43.8% |
| | Total | 4.3% | 12.4% | 39.7% | 43.5% |
| Science projects | non-Aboriginals | 13.6% | 44.9% | 30.9% | 10.6% |
| | Aboriginals | 15.1% | 36.9% | 31.2% | 16.8% |
| | Total | 13.7% | 44.4% | 30.9% | 11.0% |
| Work in groups | non-Aboriginals | 10.2% | 36.1% | 38.6% | 15.1% |
| | Aboriginals | 13.2% | 32.2% | 38.1% | 16.4% |
| | Total | 10.4% | 35.8% | 38.6% | 15.2% |
| Do experiments | non-Aboriginals | 24.3% | 47.7% | 22.2% | 5.8% |
| | Aboriginals | 32.3% | 38.6% | 23.2% | 6.0% |
| | Total | 24.9% | 47.0% | 22.2% | 5.8% |
| Teacher shows experiments | non-Aboriginals | 18.0% | 48.8% | 26.8% | 6.4% |
| | Aboriginals | 21.0% | 40.7% | 30.2% | 8.1% |
| | Total | 18.2% | 48.2% | 27.0% | 6.5% |
| Quiz or test | non-Aboriginals | 3.6% | 67.5% | 23.2% | 5.8% |
| | Aboriginals | 4.7% | 57.5% | 28.7% | 9.1% |
| | Total | 3.6% | 66.8% | 23.6% | 6.0% |
| Teacher assigns homework | non-Aboriginals | 7.9% | 16.0% | 40.1% | 36.1% |
| | Aboriginals | 10.4% | 13.4% | 36.5% | 39.7% |
| | Total | 8.1% | 15.8% | 39.8% | 36.3% |
| Teacher corrects work | non-Aboriginals | 10.2% | 23.0% | 42.5% | 24.3% |
| | Aboriginals | 8.9% | 17.6% | 42.5% | 31.0% |
| | Total | 10.1% | 22.6% | 42.5% | 24.8% |
| Discuss exams | non-Aboriginals | 13.9% | 41.8% | 34.6% | 9.8% |
| | Aboriginals | 13.8% | 37.2% | 35.9% | 13.1% |
| | Total | 13.9% | 41.4% | 34.7% | 10.0% |
| Do assignments | non-Aboriginals | 8.9% | 22.8% | 42.4% | 25.9% |
| | Aboriginals | 11.7% | 20.0% | 38.4% | 30.0% |
| | Total | 9.1% | 22.6% | 42.1% | 26.2% |
| Study textbook | non-Aboriginals | 16.0% | 22.8% | 35.6% | 25.5% |
| | Aboriginals | 16.2% | 20.7% | 33.7% | 29.3% |
| | Total | 16.1% | 22.7% | 35.5% | 25.7% |
| Teacher reads from textbook | non-Aboriginals | 14.4% | 18.0% | 35.7% | 31.9% |
| | Aboriginals | 13.3% | 18.8% | 32.4% | 35.6% |
| | Total | 14.3% | 18.1% | 35.5% | 32.1% |
| Teacher asks questions | non-Aboriginals | 6.9% | 15.5% | 39.8% | 37.8% |
| | Aboriginals | 10.6% | 18.7% | 37.8% | 32.9% |
| | Total | 7.2% | 15.7% | 39.7% | 37.4% |

Table 3 (continued)

| | | *Rarely or never* | *Few times a month* | *Few times a week* | *Almost every day* |
|---|---|---|---|---|---|
| Field trips | non-Aboriginals | 74.6% | 17.4% | 5.9% | 2.2% |
| | Aboriginals | 63.6% | 20.8% | 10.4% | 5.1% |
| | Total | 73.9% | 17.6% | 6.2% | 2.4% |
| Teacher helps students | non-Aboriginals | 4.8% | 11.8% | 33.4% | 50.1% |
| | Aboriginals | 7.7% | 9.4% | 30.0% | 52.8% |
| | Total | 5.0% | 11.6% | 33.1% | 50.3% |

timated with Cramer's *V*, and the percentage of variance explained by the ethno-cultural group was evaluated with Goodman and Kruskal's *tau* (Howell). Because we used successive null hypotheses tests, the Bonferroni correction was applied to keep *alpha* under 0.05 (Abdi, 2007).

Although most of the chi-square test results are statistically significant, it is probably an artifact of the high statistical power of the study. The effect sizes remain negligible according to Cohen's (1988) criteria, and the percentage of variance explained by ethno-cultural belonging does not reach 1% (Table 4). We deduce that the teaching methods do not vary greatly between teachers of Aboriginal and non-Aboriginal students, most probably because most of these students probably attend the same classes.

Table 4
Association Between Teaching Methods and Ethnocultural Group

| *Method* | *n* | $L^2[3]$ | *p* | *V* | τ | *p* |
|---|---|---|---|---|---|---|
| Teacher writes notes | 15,064 | 11.435 | 0.010 | 0.028 | 0.000 | 0.014 |
| Solve problems | 15,036 | 15.214 | 0.002* | 0.034 | 0.000 | 0.155 |
| Science projects | 15,018 | 45.043 | 0.000* | 0.057 | 0.001 | 0.000 |
| Work in groups | 15,003 | 13.160 | 0.004 | 0.030 | 0.000 | 0.012 |
| Do experiments | 14,986 | 40.607 | 0.000* | 0.053 | 0.001 | 0.000 |
| Shows experiments | 14,981 | 25.686 | 0.000* | 0.041 | 0.001 | 0.000 |
| Quiz or test | 15,003 | 44.146 | 0.000* | 0.056 | 0.002 | 0.000 |
| Assigns homework | 15,001 | 17.448 | 0.001* | 0.034 | 0.000 | 0.001 |
| Teacher corrects work | 14,964 | 30.550 | 0.000* | 0.045 | 0.001 | 0.000 |
| Discuss exams | 14,940 | 15.192 | 0.002* | 0.033 | 0.000 | 0.003 |
| Do assignments | 14,918 | 20.121 | 0.000* | 0.037 | 0.000 | 0.000 |
| Study textbook | 14,943 | 8.064 | 0.045 | 0.023 | 0.000 | 0.032 |
| Reads from textbook | 14,950 | 8.277 | 0.041 | 0.024 | 0.000 | 0.013 |
| Teacher asks questions | 14,899 | 28.611 | 0.000* | 0.045 | 0.000 | 0.000 |
| Field trips | 14,938 | 75.639 | 0.000* | 0.077 | 0.002 | 0.000 |
| Teacher helps students | 14,985 | 24.153 | 0.000* | 0.042 | 0.000 | 0.002 |

*Significant at the 0.003 level (Bonferroni correction used).

*Hypothesis #1: No particular teaching method stands out as particularly effective in leading to Aboriginal students' achievement*

To try to refute this hypothesis, we carried out univariate analyses of covariance (ANCOVA) for which the dependent variable was the test score and the independent variable was the frequency of use of the targeted teaching method. Again, the Bonferroni correction of alpha was used. These analyses were performed only on the Aboriginal subsample, and the effect of gender and age was controlled. The effect size was estimated with *omega-square*. Our analyses suggest that success is less associated with the selection of a specific method than with a judicious dosage of several methods (Tables 5 and 6).

The frequency of use of more than half the methods would have nearly no effect on test scores (Table 5). Thus in the case where the teacher writes on the blackboard ($F$[3]=1.141, $p$=0.331, $\omega^2$=0.000), gives homework ($F$[3]=2.031, $p$=0.108, $\omega^2$=0.003), corrects students' work ($F$[3]=0.454, $p$=0.715, $\omega^2$=–0.001), discusses exams ($F$[3]=1.416, $p$=0.237, $\omega^2$=0.001), asks questions ($F$[3]=1.731, $p$=0.159, $\omega^2$=0.002) or helps students ($F$[3]=2.540, $p$=0.055, $\omega^2$=0.004), or when students are solving problems ($F$[3]=3.974, $p$=0.008, $\omega^2$=0.008), working in groups ($F$[3]=3.860, $p$=0.009, $\omega^2$=0.008), doing experiments in the laboratory ($F$[3]=2.616, $p$=0.050, $\omega^2$=0.004), and doing assignments ($F$[3]=3.564, $p$=0.014, $\omega^2$=0.007), the frequency of use is not associated with statistically significant variations of the test results, despite the high statistical power. In addition, the observed effect sizes are negligible. However, a variation in frequency would be associated with varied levels of performance for six of the teaching methods. Thus for some methods, more seems to be better. This is the case for studying

Table 5
Science Education Test Score of Aboriginal Students According to the Frequency of Use of Teaching Methods (ANCOVA)

| *Method* | *n* | *F[3]* | *p* | $\omega^2$ |
|---|---|---|---|---|
| Teacher writes notes | 1,031 | 1.141 | 0.331 | 0.000 |
| Solve problems | 1,031 | 3.974 | 0.008 | 0.008 |
| Science projects | 1,027 | 5.821 | 0.001* | 0.013† |
| Work in groups | 1,026 | 3.860 | 0.009 | 0.008 |
| Do experiments | 1,020 | 2.616 | 0.050 | 0.004 |
| Teacher shows experiments | 1,022 | 5.484 | 0.001* | 0.012† |
| Quiz or test | 1,025 | 9.134 | 0.000* | 0.022† |
| Teacher assigns homework | 1,022 | 2.031 | 0.108 | 0.003 |
| Teacher corrects work | 1,024 | 0.454 | 0.715 | –0.001 |
| Discuss exams | 1,021 | 1.416 | 0.237 | 0.001 |
| Do assignments | 1,019 | 3.564 | 0.014 | 0.007 |
| Study textbook | 1,015 | 5.419 | 0.001* | 0.012† |
| Teacher reads from textbook | 1,015 | 5.575 | 0.001* | 0.013† |
| Teacher asks questions | 1,010 | 1.731 | 0.159 | 0.002 |
| Field trips | 1,015 | 6.304 | 0.000* | 0.015† |
| Teacher helps students | 1,020 | 2.540 | 0.055 | 0.004 |

*Significant at the 0.003 level (Bonferroni correction used).
† Small effect (Cohen, 1988).

Table 6
Score by Group and Teaching Method
95% Confidence Interval for Estimated Marginal Means

| | | *Rarely or never* | *Few times a month* | *Few times a week* | *Almost every day* |
|---|---|---|---|---|---|
| Teacher writes notes | non-Aboriginals | [0.498, 0.512] | [0.507, 0.517] | [0.516, 0.523] | **[0.521, 0.527]** |
| | Aboriginals | [0.428, 0.460] | **[0.457, 0.483]** | [0.458, 0.476] | [0.461, 0.475] |
| Solve problems | non-Aboriginals | [0.482, 0.501] | [0.504, 0.515] | [0.516, 0.522] | **[0.523, 0.529]** |
| | Aboriginals | [0.400, 0.438] | **[0.466, 0.495]** | [0.459, 0.475] | [0.460, 0.475] |
| Science projects | non-Aboriginals | [0.513, 0.524] | **[0.529, 0.535]** | [0.506, 0.513] | [0.493, 0.505] |
| | Aboriginals | [0.430, 0.456] | **[0.476, 0.492]** | [0.451, 0.468] | [0.446, 0.470] |
| Work in groups | non-Aboriginals | [0.504, 0.516] | **[0.526, 0.532]** | [0.514, 0.520] | [0.507, 0.517] |
| | Aboriginals | [0.428, 0.455] | **[0.471, 0.488]** | [0.457, 0.473] | [0.450, 0.474] |
| Do experiments | non-Aboriginals | [0.509, 0.517] | **[0.528, 0.534]** | [0.507, 0.515] | [0.484, 0.499] |
| | Aboriginals | [0.447, 0.464] | **[0.468, 0.484]** | [0.453, 0.473] | [0.445, 0.486] |
| Teacher shows experiments | non-Aboriginals | [0.514, 0.523] | **[0.526, 0.531]** | [0.508, 0.515] | [0.488, 0.503] |
| | Aboriginals | [0.441, 0.462] | **[0.476, 0.491]** | [0.448, 0.466] | [0.433, 0.467] |
| Quiz or test | non-Aboriginals | [0.491, 0.510] | **[0.528, 0.532]** | [0.498, 0.505] | [0.472, 0.488] |
| | Aboriginals | [0.408, 0.454] | **[0.474, 0.487]** | [0.446, 0.464] | [0.411, 0.444] |
| Assigns homework | non-Aboriginals | [0.494, 0.508] | [0.511, 0.521] | [0.519, 0.524] | **[0.521, 0.527]** |
| | Aboriginals | [0.431, 0.461] | [0.440, 0.467] | **[0.463, 0.479]** | [0.462, 0.478] |
| Teacher corrects work | non-Aboriginals | [0.514, 0.526] | **[0.525, 0.533]** | [0.518, 0.524] | [0.506, 0.513] |
| | Aboriginals | [0.439, 0.472] | [0.448, 0.471] | **[0.463, 0.478]** | [0.457, 0.475] |
| Discuss exams | non-Aboriginals | [0.513, 0.523] | **[0.526, 0.532]** | [0.511, 0.518] | [0.494, 0.507] |
| | Aboriginals | [0.444, 0.470] | **[0.465, 0.482]** | [0.458, 0.475] | [0.443, 0.470] |
| Do assignments | non-Aboriginals | [0.500, 0.513] | [0.509, 0.517] | [0.518, 0.524] | **[0.525, 0.533]** |
| | Aboriginals | [0.420, 0.449] | [0.449, 0.471] | [0.462, 0.478] | **[0.468, 0.486]** |
| Study textbook | non-Aboriginals | [0.510, 0.520] | [0.517, 0.525] | [0.517, 0.523] | **[0.519, 0.526]** |
| | Aboriginals | [0.428, 0.453] | [0.454, 0.476] | [0.452, 0.469] | **[0.478, 0.496]** |
| Teacher reads from textbook | non-Aboriginals | [0.512, 0.522] | [0.508, 0.517] | [0.516, 0.522] | **[0.523, 0.530]** |
| | Aboriginals | [0.448, 0.475] | [0.425, 0.448] | **[0.473, 0.490]** | [0.464, 0.480] |
| Teacher asks questions | non-Aboriginals | [0.492, 0.506] | [0.500, 0.510] | [0.512, 0.518] | **[0.532, 0.538]** |
| | Aboriginals | [0.433, 0.463] | [0.444, 0.467] | [0.460, 0.476] | **[0.466, 0.483]** |
| Field trips | non-Aboriginals | **[0.527, 0.531]** | [0.506, 0.515] | [0.450, 0.465] | [0.450, 0.476] |
| | Aboriginals | **[0.471, 0.483]** | [0.444, 0.466] | [0.428, 0.459] | [0.399, 0.443] |
| Teacher helps students | non-Aboriginals | [0.474, 0.491] | [0.507, 0.518] | [0.514, 0.521] | **[0.524, 0.529]** |
| | Aboriginals | [0.408, 0.444] | **[0.455, 0.487]** | [0.459, 0.477] | [0.463, 0.476] |

the textbook ($F$[3]=5.419, $p$=0.001, $\omega^2$=0.012) and the teacher reading from the textbook ($F$[3]=5.575, $p$=0.001, $\omega^2$=0.013), the almost daily frequency of which is associated with the highest grade averages among Aboriginal students. However, for field trips ($F$[3]=6.304, $p$=0.000, $\omega^2$=0.015) it appears that moderation is called for, because increasing the frequency of this activity seems associated with a continual reduction in test scores. Recourse monthly to science projects ($F$[3]=5.821, $p$=0.001, $\omega^2$=0.013), the teacher showing students experiments ($F$[3]=5.484, $p$=0.001, $\omega^2$=0.012), and tests or quizzes ($F$[3]=9.134, $p$=0.000, $\omega^2$=0.022) corresponds to a higher grade average than a rarer or more frequent

use of these methods. In all these cases, the effect size barely goes beyond 1% of the explained variance (Table 6).

We also note that the highest averages associated with each method for Aboriginal students vary between the confidence interval [0.455, 0.487] (teacher helps students a few times a month) and [0.478, 0.496] (study textbook almost every day). Because the intervals overlap, it would be ill advised to conclude that one method is superior to another. Consequently, our results do not lead to refutation of the hypothesis that no method fits better than others with Aboriginal students.

*Hypothesis #2: No difference between Aboriginal and non-Aboriginal students exists regarding the effectiveness of teaching methods*

To verify whether the various teaching methods had varied effects on test results among non-Aboriginals and Aboriginals, we carried out a univariate analysis of covariance (ANCOVA) for each method, paying particular attention to the interaction effect between method and ethnocultural group. We controlled the effects of gender and age by including them as covariates. The effect size was estimated with *omega-square* and the Bonferroni correction was used.

Several results were statistically significant at the 0.003 level. However, none of the effect sizes reached the threshold of 0.0099, which is the lower boundary for considering an effect as small as proposed by Cohen (1988, Table 7). In fact, the greatest effect yielded an *omega-square* of 0.001. By way of comparison, *omega-square* varied from 0.069 to 0.077 for age, from 0.001 to 0.003 for sex, from 0.005 to 0.023 for the main effect of group, and from 0.000 to 0.011 for the main effect of method. Consequently, we must conclude that the effects of the various teaching methods on achievement in science education are practically the same for both non-Aboriginals and Aboriginals in our sample, which does not allow for refutation of our second research hypothesis.

## *Discussion*

The literature on the teaching methods that should be advocated for Aboriginal students identifies field trips, project-based approaches, peer-learning, and storytelling as the most conducive to success. Yet Irvine and York (1995) did not observe any solid empirical base to sustain this belief in their critical review of the literature. Our results support the skepticism expressed by these authors. The methods recommended do not distinguish themselves from other methods in terms of efficiency and generally only seem to have a marginal effect on test achievement. In addition, they are associated with better results when used either rarely or never (field trips) or at most a few times a month (projects). As for the methods that are most criticized and correspond to a lecture-style approach, they have the maximum efficiency when used frequently (study textbook and teacher gives a formal presentation based on the textbook). However, in the light of these results, we must mention two important caveats. First, our analyses do not enable us to establish a *causal* relationship between the use of a particular teaching method and test results. Indeed, our results do not even convincingly establish precedence of cause over effect (i.e., demonstrate that when the cause is present, the effect is systematically observed), let alone reactivity of effect to cause or a mechanism explaining how the cause produces

Table 7
Science Education Test Scores According to Ethnocultural Belonging and Teaching Methods (ANCOVA)

| *Method x Cultural Group* | *n* | *F[3]* | *p* | $\omega^2$ |
|---|---|---|---|---|
| Teacher writes notes | 16,072 | 1.304 | 0.271 | 0.000 |
| Solve problems | 16,044 | 4.758 | 0.003* | 0.001 |
| Science projects | 16,023 | 5.052 | 0.002* | 0.001 |
| Work in groups | 16,006 | 1.777 | 0.149 | 0.000 |
| Do experiments | 15,983 | 2.716 | 0.043 | 0.000 |
| Teacher shows experiments | 15,980 | 3.201 | 0.022 | 0.000 |
| Quiz or test | 16,006 | 0.959 | 0.411 | –0.000 |
| Teacher assigns homework | 16,000 | 0.693 | 0.556 | –0.000 |
| Teacher corrects work | 15,966 | 4.065 | 0.007 | 0.000 |
| Discuss exams | 15,939 | 1.331 | 0.262 | 0.000 |
| Do assignments | 15,916 | 2.050 | 0.105 | 0.000 |
| Study textbook | 15,935 | 8.150 | 0.000* | 0.001 |
| Teacher reads from textbook | 15,942 | 7.967 | 0.000* | 0.001 |
| Teacher asks questions | 15,887 | 1.544 | 0.201 | 0.000 |
| Field trips | 15,930 | 6.112 | 0.000* | 0.001 |
| Teacher helps students | 15,982 | 1.015 | 0.385 | 0.000 |

*Significant at the 0.003 level (Bonferroni correction used).

the effect. Therefore, we should not infer that frequent use of field trips *causes* reduced performance or that daily exposure to lectures *causes* increased performance in science education. At most, we can say that the frequency of use of these practices is *associated with* a certain level of achievement, and not to a great extent. Next, our data do not enable us to differentiate between students on or off reserves, or between status and non-status Indians, although only 56.9% of status Indians lived on a reserve according to the 2004 census (Indian and Northern Affairs Canada, 2005). It is possible that pedagogical practices differ according to school location. Although it is not probable that provincially controlled schools adapt their methods to the Aboriginal clientele, band-operated schools possibly do, but they are not sampled by the SAIP program.

Incidentally, research on learning styles assumes the existence of distinctions between Aboriginals and non-Aboriginals in cognitive processing of information. In consequence, authors who subscribe to this position claim that a single teaching method may produce varied results in terms of performance among Aboriginal and non-Aboriginal students. Yet our results show that although teaching methods seem to have varied effects on achievement between Aboriginals and non-Aboriginals, these differences remain marginal as they explain no more than 1% of the total variance of the dependent variable. Thus we conclude that Aboriginals and non-Aboriginals 13- and 16-year-olds enrolled in science class in a Canadian public school react essentially in the same way in terms of performance to the various teaching methods. Our results tend, therefore, to contradict the thesis that evokes cognitive differences

and mismatch between learning styles and teaching methods to explain the difficulties displayed by Aboriginal students in science education.

These findings seem rather surprising: They suggest that the views on the necessity of modifying pedagogical approaches in Aboriginal classrooms in order to stick more closely to the students' learning styles and thus encourage their success, receive little if any empirical support. What seems to matter most is a wise dosage of a variety of methods, some being more beneficial when used frequently and others when applied parsimoniously. Yet the effect on achievement would be practically insignificant. This is not a trite result: It suggests that teachers' pedagogical choices may have only marginal effects on students' academic results. This goes against well ingrained beliefs in education and the recent waves of educational reforms advocating a switch from teacher-centered to learner-centered approaches. Yet several alternative explanations seem plausible. First, the test format might favor those students more exposed to traditional, teacher-centered methods and thus mask the effects of the more current pedagogical trends. Second, our sample does not include Aboriginal students schooled on reserve and might thus be slightly biased as to the kind of Aboriginal students included in the analyses. This would be the case if there are relevant differences between Aboriginal students electing to enroll in an off-reserve school and those schooled on reserve as some studies seem to suggest (Larose, Bourque, Terrisse, & Kurtness, 2001). Third, a large sample and independent variables with broadly defined categories might cause some kind of regression to the mean, precluding the identification of subtle effects of teaching methods. For example, the category of non-Aboriginal students includes students of Canadian as well as immigrant origin of all provinces and a variety of settings (rural and urban, big and small schools, etc.).

## *Conclusion*

### *Summary*

This study tested two hypotheses: (a) no particular teaching method stands out as particularly effective in leading to achievement in Aboriginal students, and (b) no difference between Aboriginal and non-Aboriginal students exists regarding the effectiveness of teaching methods. Our results with 13- and 16-year-old students enrolled in science class suggest that none of the methods singularly distinguish themselves as particularly efficient, but that the frequency of use for each method could be associated with fluctuations in performance. However, the frequency of use of diverse methods only marginally contributes to explain the variance in test scores. In addition, the associations between methods and performance do not seem to vary significantly according to students' ethnocultural background, which points to a similarity in learning styles (insofar as we agree that groups showing different learning styles from one another should react differently to specific teaching methods). If such is the case, we may then question the plausibility of the thesis of a mismatch between learning styles and teaching methods to explain the lack of success among Aboriginal students in science education. Finally, our results bring us to another finding, according to which the choice of teaching method would have little influence on test achievement.

*Ideas for Future Research*

We believe that this study sheds new light on the issue of learning styles in Aboriginal education. Increasingly, it appears that empirical bases for adapting teaching methods to learning styles that are supposedly peculiar to Aboriginal students remain elusive. Nevertheless, we suggest an additional and nearly unexplored research avenue: adapting performance measures to a diversity of pedagogical approaches. Although pedagogical trends have diversified considerably in the last two decades, standard learning assessment has remained strangely monolithic. Yet the arrival of new pedagogical approaches has coincided with the development of new assessment modes. These are, however, not applied in standard assessments, which may consequently draw a biased picture of the level of performance of an increasing number of students who benefit from a renewed teaching approach. Therefore, an interesting replication of this study could offer several modes of assessing skill level and analyze the variation in performance associated with the measuring method, by checking, for example, whether the results are superior when the teacher's pedagogical approach and the mode of assessment coincide. This raises another question: if adapting to a given learning style requires adjusting both teaching method and assessment modes, is it possible to establish a common metric that would allow the comparison of nothing more than the effect of teaching methods (by controlling the performance measure effect)? As long as we have not taken up this challenge, it will be difficult to reject completely the possibility of distinct learning styles.

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