Interdependence Revisited: Mathematics Achievement in an Intensified French Immersion Program

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Abstract: This study examines the effect of teaching mathematics in French on mathematics achievement evaluated in English. In this context it analyzes the effect of increased intensity of bilingual education on mathematics achievement. It also analyzes the effects of language of testing in the context of French immersion at the intermediate level. The participants in the study are two cohorts of French immersion pupils followed from Grades 4-7. The treatment group received 80% of the core academic curriculum, including mathematics, in French and 20% in English. The comparison group received 50% of the core academic curriculum in French and 50%, including mathematics, in English. Achievement in mathematics was measured for both groups at the end of Grade 6. Analyses of covariance showed an advantage in mathematics for the 80% French group compared to the 50% French group. These results provide further evidence for Cummins' threshold hypothesis and interdependence hypothesis.

Résumé : Cette étude examine l'effet de l'enseignement des mathématiques en français sur le rendement en mathématiques évalué en anglais. De plus, elle analyse les effets d'un programme bilingue intensifié sur le rendement en mathématiques. L'étude analyse aussi l'influence de la langue dans laquelle l'évaluation est faite, dans le contexte de l'immersion française au niveau intermédiaire. Les participants à l'étude sont deux cohortes d'élèves d'immersion française suivies de la quatrième à la septième année. Le groupe expérimental a reçu 80 % de l'enseignement de son programme académique, y compris les mathématiques, en français et 20 % en anglais. Le groupe de comparaison a reçu 50 % de son programme académique en français et 50 %, y compris les mathématiques, en anglais. Le rendement en mathématiques des deux groupes fut mesuré à la fin de la sixième année. Les analyses de covariance ont montré un avantage en mathématiques pour le groupe recevant 80 % de son enseignement en français comparé au groupe recevant 50 % de son enseignement en français. Les résultats supportent les hypothèses de seuil et d'interdépendance de Cummins.

Introduction

Theoretical hypotheses or principles do not easily convince parents when it comes to their children's educational welfare. This is one of the reasons that this study was undertaken, as part of a larger four-year longitudinal study of second language intensification in a French immersion school located in an anglophone community in Vancouver, Canada. The main study was designed to assess the efficacy of increasing the teaching of core academic subjects in French from 50% to 80%, and conversely reducing the core academic instruction in English from 50% to 20%, through the four intermediate school years. Teaching mathematics in French, instead of in English as had been done previously, maintained the amount of core academic instruction in French at about 80%, rather than reducing it to about 50% from Grade 4 onward. However, many parents were concerned that their children might not understand and learn mathematics as well as if the subject were taught in English. Thus, the main purpose of the present study was to investigate the effect on mathematics achievement evaluated in English, in a French immersion program where the intensity of French instruction had been increased from its usual 50% to approximately 80% throughout the intermediate school years by teaching mathematics in French.

At the same time, the effect of increased intensity of bilingual education on mathematics achievement is considered. The present article will describe the context of the main study and of the mathematics study, and report the results of the latter. The main study's interim results on English and French literacy appear in the Canadian Modern Language Review (Reeder, Buntain, & Takakuwa, 1999).

Context: The main study

The main study was undertaken to evaluate increased intensity of French exposure, which was provided 'in an attempt to overcome a perceived plateau effect in second language learning in the standard model of early French immersion instruction' (Reeder et al., 1999, p. 50), in accordance with studies that have indicated a positive correlation between time spent learning a second language and proficiency (Carey, 1991; Gray, 1981; Lapkin, Hart, & Harley, 1998). In the mid-1990s, the administrator of an elementary French immersion school in the Vancouver school district decided, with her staff, to maintain primary school second language intensity throughout the intermediate school years (Grades 4-7) by teaching approximately 80% of the core academic curriculum (mathematics, science, social studies, French language arts - i.e., all subjects but English language arts) in French. From kindergarten through Grade 2, students had received all of their instruction in French. In the revised Grade 4-7 program, English was to remain the only core academic subject taught in English. By learning mathematics in French instead of English, students in the treatment group stood to gain at least 600 hours of instruction in French. Furthermore, because the administrator attempted to assign francophone teachers to the non-core subject areas whenever possible, 'the net gain could be closer to the 900- to 1,000-hour range by the end of the four-year study, or an increase of 225 to 250 hours per year of French language experience for the higher-intensity French program group' (Reeder et al., 1999, p. 57). The questions of the main study were:

What are the effects of increasing French language intensity to 80% in the intermediate school years on French oral and literate proficiencies?
What is the effect of increasing French language intensity to 80% and reducing English core academic teaching to 20% in the intermediate school years on English literate proficiency?

In the year of the policy change, the school's 45 Grade 4 students (the treatment group) followed the newly introduced 80% French, 20% English program, whereas the school's 36 Grade 5 students (the comparison group) continued to follow the previously-established 50% French, 50% English intermediate program.

Preliminary results from the French-English literacy phase of the main study (Reeder et al., 1999) showed that better performance on French descriptive writing was associated with higher intensity of French language program delivery, whereas there was no difference between the two groups in narrative writing or reading comprehension. On the English measures, better English comprehension was associated with lower intensity of French language program delivery, whereas there was no difference between the two groups on the other measures, narrative writing and descriptive writing.

The mathematics study was undertaken when, at the end of Grade 5, some of the treatment group's parents expressed concern about the school's decision to teach intermediate mathematics in French. In the school system in which the study was conducted, mathematics is taught in English within the secondary school (Grades 8-12) French immersion program. Parents wanted to know whether their children in the 80%/20% group would be at a disadvantage in secondary school relative to their immersion peers who had received their mathematics education in English in Grades 4-7. Thus, the specific research questions discussed in the present article are:

Would the 80% group be at a disadvantage academically when mathematics was taught in French?
Would the 80% group perform as well as the group taught mathematics in English on a standardized mathematics test administered in English?

While some of the parents expressed concern that the 80% group would not do as well as the 50% group when mathematics achieve- ment was subsequently evaluated in English, the researchers' hypothesis was that there would be no disadvantage differed due to what is known in the literature on learning content in a second language and language of testing.

Background of the study and theoretical framework

Learning content in a second language

Large-scale studies done in the early days of French immersion education in Canada (Genesee, 1987; Swain & Lapkin, 1982) show that results of mathematics testing using standardized tests in English are comparable for English program students and early French immersion students. In many cases, French immersion students do better than their English program counterparts. This is shown at the primary level (K-Grade 3) when French immersion students are taught mathematics in French. One exception is arithmetic word problems, where French immersion students tend to score lower than English program students when evaluated in English. The difference disappears after French immersion students have learned to read in English. However, these studies were conducted within regular French immersion programs where English is usually introduced in Grade 3 or 4, and where approximately half of the curriculum is taught in English and half in French from Grades 4-7. In many cases, mathematics is part of the curriculum taught in English.

No studies had been conducted on this topic since these early large-scale studies, and one could assume that educational conditions have changed. Nevertheless, a recent report on French immersion students' results on Grade 3 and Grade 6 provincial tests in Ontario (Turnbull, Hart, & Lapkin, 2000) corroborates the results of earlier large-scale studies in Canada. In that study, districts had the choice of administering the mathematics tests in English or translated into French. For Grade 3, most districts chose mathematics tests in translation, especially if their program was full immersion until Grade 3, whereas for Grade 6 very few districts chose the French translation. In Grade 3, achievement in mathematics was similar for French immersion and non-French immersion students. In Grade 6, immersion students outperformed non-immersion students in mathematics (Turnbull et al., 2000, p. vii).

From a theoretical point of view, the 'threshold hypothesis' (Cummins & Swain, 1986) indicates that 'linguistic, cognitive, and academic advantages are associated with high levels of proficiency in both first and additional languages' (p. xvi). Therefore, higher intensity, defined as more time spent learning academic content in a second language, should produce higher proficiency in the second language and, as a result, higher academic achievement. As their second language proficiency improves, students should better understand new mathematical concepts taught in French.

Nevertheless, a recent large-scale quasi-experimental longitudinal study conducted in a late immersion program in Hong Kong by Marsh, Hau, and Kong (2000) indicates negative effects of instruction in English (second language) on mathematics achievement and other non-language subjects (history, geography, and science). The authors argue that the program 'was a failure in terms of providing academic benefits for Hong Kong students, as well as supporting predictions based on previous immersion research and Cummins' theory' (p. 339). However, that study, even though significant and important, could not be expected to yield results comparable to the present

study because its context is quite different from that of the Canadian immersion study. First, this study concerned late immersion, starting at the high school level where the threshold of L2 competency needed to achieve benefits from immersion might be much higher than the threshold needed in early immersion (Cummins, 1979). Second, the language achievement level relative to that of other students was measured with only written tests; there was no indication of the students' fluency. Third, as the program was near-universal, with little ESL 'bridging' instruction available to students entering from Chinese language programs, it is possible that both low initial student proficiency in English and lack of L2 support compromised students' content learning. Finally, the authors indicate that the teachers of non-language subjects may not all have been highly fluent in English.

On the basis of the threshold hypothesis and previous research, the present research team therefore predicted that the high intensity immersion group would not be academically disadvantaged in mathematics if that subject was taught in French. However, we still did not know the consequences of students' learning mathematics in French when achievement was evaluated with a test administered in English.

Language of testing

Language of testing is becoming an important issue with globalization and movement of populations. Are students disadvantaged when evaluated in a language other than their first, or in a language other than the one in which they learned a subject? From another perspective, language of testing is an issue of the validity of a test for a given population. Do the test results represent the true potential of the students?

The theory of interdependence (Cummins & Swain, 1986) indicates that 'some aspects of linguistic proficiency are cross lingual. This means that for those aspects of language proficiency which are interdependent across languages, instruction in one language will benefit both languages' (p. xviii). Most studies of achievement in mathematics support this hypothesis, especially when students are administered mathematics tests in their first language and that language is the dominant language of the society, in a situation of 'additive bilingualism' (Lambert, 1977). In Genesee's study (1987), testing was done in English, and the results were positive for French immersion students except for word problems in early grades when students had not yet learned to read in English. Other studies (Lambert & Tucker, 1972) using parts of the (English language) Metropolitan Achievement Test of the Lorge-Thorndike Test (1959) and in French with the Test de rendement en calcul from the Montreal Catholic School Board (undated, as cited in Lambert & Tucker, 1972, p. 32), showed no differences between French immersion students and francophone students. Cummins commented on language of testing to measure academic achievement in the previous studies in light of his interdependence hypothesis:

As has been noted, the students were usually tested in their first language although they were taught mathematics and science in their second language. This does not seem to have handicapped the students as was suspected. This adds credence to Cummins' (1981) 'interdependence hypothesis' which suggests that cognitive academic knowledge is held in common storage and underlies the ability to understand or express it in either language given adequate levels of linguistic proficiency in both languages. In this case, the immersion students gained the knowledge in one language but made full use of it in the other language context, both activities being dependent upon a threshold level of linguistic competence in each language. (Cummins & Swain, 1986. p. 39)

Furthermore, de Courcy and Burston (2000) conducted a study about language of mathematics

testing in an Australian early partial immersion program. In this program, children are instructed in French 45% of the time and in English 55% of the time, from kindergarten to Grade 6. Mathematics is taught in French during the entire program. Students take a mathematics test each year, half of them in English and the other half in French (the tests were translated from English to French). In the first year of the testing, there was no significant difference between the results of the group who took the test in English and the other group who took the test in French. By Grade 5, students taking the test in English did significantly better than students who took the test in French. Although this study shows that students had no trouble learning mathematics in French and taking the test in English, it is important to note that it was done in a partial immersion program and we could not assume that the results would be the same in an early total immersion program.

Finally, the most recent report (Turnbull et al., 2000), noted above, showed that there were no differences between the French immersion students and the regular program students in Grade 3 and that, in Grade 6, French immersion students' scores were superior to those of regular program students. Turnbull et al. explain the difference between Grade 3 and Grade 6 by saying that the Grade 3 results 'did not really reflect the greater academic strength of immersion students' (p. 24), and they propose the 'extended lag hypothesis' (p. 24). This lag in development is remedied after Grade 3, when students accumulate more hours of instruction in English. This hypothesis could explain Genesee's results, too.

However, it could also be argued that concepts in mathematics become increasingly difficult at the intermediate level and that students may have difficulty understanding them if these are explained in their second language, especially if their academic language proficiency is not at a sufficient level. That students may have difficulty understanding them would be due to problems involving comprehensibility of input and is a likely factor in the Hong Kong late immersion results.

To our knowledge, no evaluation of mathematics in French immersion has been done in English at the end of the intermediate years when mathematics has been taught in French since kindergarten. This was one of the motivations for conducting the present study.

Method

Setting and participants

The study took place in a single-track French immersion school of approximately 300 students in the Vancouver district. The school was located in a predominantly middle- to upper-middle-socio-economic class community, characterized by higher than average incomes, and parental educational levels and extensive parental involvement and interest in children's education. Only 4% of the students had English as a second or additional language compared to 15-35% in immediately neighbouring Vancouver schools (Gunderson, 1995).

At the outset of the longitudinal study, the treatment group consisted of 45 students and the comparison group consisted of 36 students. As the class size maximum (as per the Teachers' Collective Agreement) is 30 students at the intermediate level, the two groups were assigned to different teachers each year of the study. Therefore, students in the study were exposed to a number of different teachers (both francophones and anglophones) and class composition varied over the course of the three years previous to this comparison. This was an advantage to the present research because outcomes were less likely to be due to teacher effect. By the end of Grade 6, 71 participants were available for testing. Because some students were absent on a day when one of the measures was administered and thus could not be included in the analysis, findings are based on data from 36 students in the treatment group and 30 in the comparison group.

Longitudinal design and data collection

A longitudinal, two-cohort, quasi-experimental design was employed. The mathematics study took place at the end of Grade 6 within the longitudinal study, for which assignment of teachers to grade level was held constant across the program groups for the four-year period. The school assigned all students who began Grade 4 as of September 1995 to an 80% French/20% English program for the balance of their elementary schooling (to the end of Grade 7). This group served as the treatment group. Students in higher grades followed the previous program from Grade 4 to Grade 7 (50% English/50% French). The group that entered Grade 5 in September 1995 served as the comparison group. Figure 1 shows the design of the data collection plan for the two cohorts participating in the larger longitudinal study. Although all the measures

FIGURE 1

Design and data collection plan

End of Year 1: End of Year 2: End of Year 3: End of Year 4:
May 1996 May 1997 May 1998 May 1999

Treatment group: Grade 4 Grade 5 Grade 6 Grade 7
Grade 4 as of Sept. Math

1995 (80% Group) testing

Comparison group: Grade 5 Grade 6 Grade 7

Grade 5 as of Sept. Math

1995 (50% Group) testing

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were administered at the end of each year, the measure of mathematics achievement was administered only once, at the end of Grade 6.

Mathematics test

The Stanford Diagnostic Mathematics Test, Third Edition (SDMT3), Brown Level Form H (Beatty, Gardner, Madden, & Karlsen, 1984) was chosen to measure (in English) the achievement in mathematics of both treatment and comparison groups. According to the technical manual of the test, reliability is fairly high for Form H (> .86). The manual reports that the criterion-related validity has been calculated by correlating the test and its sub-tests to the Advanced Level

Mathematics Test of the Stanford Achievement Test. All values exceed .66 and constitute reasonable evidence of validity. This test was developed and normed in the United States. As its name implies, it is designed to identify those specific mathematical concepts and skills on which a student is making less than satisfactory progress. Covering the mathematical content of Grades 1-8, the test is divided into four levels (two grades per level) and three areas: Number System and Numeration, Computation, and Applications. The Brown Level of the test (for Grades 6-8) measures proficiency with the concepts and skills of numeration, patterns and functions, tables and graphs, statistics, probability, and problem solving, as well as computational skills using the four arithmetical operations with whole numbers, multiple operations, and operations with decimals and fractions.

Mathematics program

The treatment group was taught mathematics in French, whereas the comparison group was taught mathematics in English. Mathquest (Kelly,

Symington, Worth, Alexander, & Klassen, 1986) and Journeys in Math (Connelly et al., 1987) were the textbooks utilized in the school at the time of the study, and the comparison group continued to use these materials throughout the study. The staff selected the newly released French edition of the math program, Interactions (Hope & Small, 1996), for the implementation of the 80% enhanced program. As its name implies, the teaching and learning activities in Interactions are designed to be interactive in nature, placing a considerable emphasis on group problem solving, discussion, and exchange of ideas and strategies. Staff and parents fully supported the idea of teaching mathematics in French as conceived by the administrator of the school. Yet, according to reports from the staff, a number of parents from the treatment group asked to have a copy of the English edition of the manual at home in order to be able to help their children with their homework.

Covariate measure

Since this study is a quasi-experiment, subjects were not randomly assigned to treatment but were included as they occurred 'naturally' in their school. A covariate was thus used in the analysis to reduce bias by equating the two groups statistically on general language proficiency (Glass & Hopkins, 1984, p. 492). We chose as our covariate an aggregate of two language measures from Grade 5: the comprehension sub-test of the Gates-MacGinitie Reading Test, second Canadian edition (MacGinitie & MacGinitie, 1992), and the Test de lecture: French reading comprehension tests for grades 2 to 6, (Barik, Swain, & Schloss et al., 1979). This aggregate of a French and an English measure also corrects somewhat for the fact that, by Grade 5, the treatment group had already received two years of treatment.

Results

Descriptive statistics

Table 1 gives the descriptive statistics for the different variables. The scores for the Gates MacGinitie reading comprehension sub-test and for the Barik et al. Test de lecture are given in T-scores (M = 50) obtained from a within-group standardization. The means of the two measures composing the covariate were higher for the treatment group than those of the comparison group. The results of the Stanford Diagnostic Mathematics Test are given in scaled scores.

TABLE 1

Descriptive statistics by intensity group

Measures	50% French			80% French		
	Mean	N	SD	Mean	N	SD
Covariate (French + English reading)	93.03	30	22.01	105.45	36	14.97
French reading (T-scores)	45.55	30	10.94	53.87	36	8.72
English reading (T-scores)	47.48	30	12.26	51.39	36	8.13
Numeration (scaled scores)	616.37	30	42.21	655.39	36	46.36
Computation (scaled scores)	593.47	30	60.20	649.69	36	42.97
Applications (scaled scores)	614.07	30	68.46	675.64	36	53.60
Total mathematics (scaled scores)	604.27	30	48.24	656.58	36	40.10

Analysis of covariance

An analysis of covariance compared the scores of the two groups in mathematics for the total results of the Stanford Diagnostic Mathematics Test and for each of its sub-tests. The covariate was the sum of the comprehension sub-test of the Gates MacGinitie Reading Test and the Barik et al. Test de lecture from Grade 5. The fixed factor was the group, treatment or comparison. Following are four tables of results. Table 2 shows the ANCOVA for the total mathematics score. Table 3 shows the ANCOVA for the Number System and Numeration sub-test, Table 4 shows the

ANCOVA for the Computation sub-test, and Table 5 shows the ANCOVA for the Applications sub-test.

Results of the analyses of covariance indicated a group effect for all the mathematics measures, with the higher French intensity treatment group being superior in all cases (see Tables 2-5). There was a statistically significant difference on the total score of the Stanford Diagnostic Mathematics Test between the treatment group and the comparison group, $F(1,63) = 13.96$, $p < .001$ after adjusting for the covariate. The treatment group performed better than the comparison group. The adjusted means were 612.93 and 649.50 respectively (see Table 2). There was a statistically significant difference on the Number System and Numeration sub-test score of the Stanford Diagnostic Mathematics Test between the treatment group and the comparison group, $F(1,63) = 5.7$,

TABLE 2

Sources of variance in mathematics performance

Eta Obs.
Source df Mean square F Sig. squared power (a)

Corrected Model (b) 2 39,591.39 27.91 .000 .470 1.000
Intercept 1 550,565.37 388.16 .000 .860 1.000

Covariate 1 34,394.96 24.25 .000 .278 .998

GROUP 1 19,804.15 13.96 .000 .181 .957

Error 63 1,418.37

(a) Computed using alpha = .05; (b) R Squared = .470 (Adjusted R Squared = .453)

TABLE 3

Sources of variance in number system and numeration performance

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Eta Obs.
Source df Mean square F Sig. squared power (a)

Corrected model (b) 2 25,567.30 15.61 .000 .331 .999
Intercept 1 597,757.98 365.02 .000 .853 1.000

Covariate 1 26,217.15 16.01 .000 .203 .976

GROUP 1 9,482.75 5.79 .019 .084 .659

Error 63 1,637.56

(a) Computed using alpha = .05; (b) R Squared = .331 (Adjusted R Squared = .310)

TABLE 4

Sources of variance in computation performance

Eta Obs.
Source df Mean square F Sig. squared power (a)

Corrected model (b) 2 43,634.75 20.48 .000 .394 1.000
Intercept 1 527,126.47 247.48 .000 .797 1.000

Covariate 1 35,534.84 16.68 .000 .209 .980

GROUP 1 23,940.48 11.24 .001 .151 .910

Error 63 2,129.97

(a) Computed using alpha = .05; (b) R Squared = .394 (Adjusted R Squared = .375)

TABLE 5

Sources of variance in applications performance

Eta Obs.
Source df Mean square F Sig. squared power (a)

Corrected model (b) 2 54,146.53 17.93 .000 .363 1.000
Intercept 1 538,804.19 178.45 .000 .739 1.000

Covariate 1 46,256.26 15.32 .000 .196 .971

GROUP 1 27,772.90 9.20 .004 .127 .848

Error 63 3,019.30

(a) Computed using alpha = .05; (b) R Squared = .363 (Adjusted R Squared = .343)

p =.019 after adjusting for the covariate. The treatment group performed better than the comparison group. The adjusted means were 623.78 and 649.21, respectively (see Table 3). There was a statistically significant difference on the Computation sub-test score of the Stanford Diagnostic Mathematics Test between the treatment group and the comparison group, F (1,63) = 11.76, p =.001 after adjusting for the covariate. The treatment group performed better than the comparison group. The adjusted means were 602.10 and 642.50, respectively (see Table 4). There was also a statistically significant difference on the Applications sub-test score of the Stanford Diagnostic Mathematics Test between the treatment group and the comparison group, F (1,63)=9.20, p =.004 after adjusting for the covariate. The treatment group performed better than the comparison group. The adjusted means were 623.92 and 667.43 respectively (see Table 5).

Discussion

The results show that, contrary to the concerns of some parents, the treatment group's performance was better than that of the comparison group on the mathematics test administered in English. The results provide evidence for Cummins' threshold and interdependence hypotheses (Cummins & Swain, 1986), as described earlier. Higher intensity in the form of increased time per day of instruction in the second language from Grades 4-6 was associated with an increase in French academic proficiency level measured by a French descriptive writing task, (Reeder et al., 1999). This increased proficiency may have assisted the treatment group in acquiring a good understanding of mathematical concepts taught in French. The results also show evidence of transfer: the students who had acquired their mathematical knowledge in French were able to retrieve it successfully in English.

Other explanations could be offered for the results. First, motivation may play some role in the pattern of results shown here. Students who study mathematics in French may expect that it will be more difficult than in English. This expectation could, in turn, motivate them to work harder and to concentrate more during the lessons. A related factor could be the sheer workload of mastering academic content in a non-native language. Higher intensity immersion students may simply have had to work harder to master the same content that their peers were acquiring by

means of English. This would result in a deeper processing of the information by the treatment group. Further, after such training, when students are tested using their native language, English, the language is much easier for them than French would be, but they may still apply themselves as they have been used to during their lessons in French. As a result, they may achieve at a higher level.

Another factor involves the fact that some parents were worried about the achievement of their children in mathematics, according to anecdotal reports from the teachers. Those parents asked to have the English manual at home in order to be able to help their children with their homework. It is possible that they provided more help with and supervision of their children's mathematics homework than they would have done had the children been taught mathematics in English. These variables could not be controlled in a classroom-based study and could have made a difference in the results.

The fact that the two groups used two different textbooks could also be a factor in the results. The treatment group used the textbook Interactions. Teaching materials that promote students' interaction, co-operation, and group work are probably more favourable to learning than methods or materials that place less emphasis on these learning variables. The difference observed between the two groups could have involved an effect of the materials used rather than the language of instruction.

Finally, this study used a quasi-experimental design in which the subjects were not assigned randomly to groups. Although an analysis of covariance was performed to equate the groups statistically, the results do not have the power provided by randomized experiments and should be taken with a degree of caution.

Summary

This study found that increasing the intensity of French in a French immersion program by teaching math in French is strongly associated with a positive effect on mathematics achievement evaluated in English. This result provides further evidence for the benefits of a higher proficiency level in the second language - especially in the domain of academic language - to school success in that language. This study also offers good evidence for transfer of knowledge from one language to the other, indicating that content learned in one language can be retrieved in the other language, provided that students have sufficient proficiency in both languages. From a policy point of view, it may be unnecessary to translate mathematics tests for French immersion students once they have achieved sufficient mastery of both languages in the later elementary school years. The case may, however, be different for domains such as social sciences, where students frequently have to write test essays. Further research is warranted to determine if the results would differ in other curricular domains. Motivation of the students and of the parents in a context of additive bilingualism and curricular innovation may also have played a role in the study's positive results.

In order to confirm these results, a treatment study should be undertaken where subjects are assigned randomly to groups and where there is a systematic attempt to control some of the potentially confounding variables discussed above. Such an experimental study could also be complemented usefully by a series of qualitative assessments of the roles played in these results by such factors as student motivation, workload, parental involvement, and the content and instructional approach in the textbooks employed.

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