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Mathematics Achievement by Immigrant Children: A Comparison of Five English-speaking Countries

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Abstract

In this study, I examined academic achievement of immigrant children in the United States, Canada, England, Australia, and New Zealand. Analyzing data from the Third International Mathematics and Science Study (TIMSS), I gauged the performance gaps relating to the generation of immigration and the home language background. I found immigrant children's math and science achievement to be lower than the others only in England, the U.S., and Canada. Non-English language background was found in each country to relate to poor math and science learning and this disadvantage was stronger among native-born children—presumably children of indigenous groups—than among immigrant children. I also examined the school variation in math performance gaps, using hierarchical linear modeling (HLM) to each country's data. The patterns in which language- and generation-related math achievement gaps varied between schools are different in the five countries.

The public school system as an institution plays a critical role educating immigrant children and facilitating their participation in the larger society. This system in the U.S., succeeded in integrating European immigrants, is now facing a serious challenge as newcomers of non-European heritage have become the primary source of immigration over the decades. This shift in origins of the immigrants is a most striking development in U.S. immigration history (Fix, Passel, Enchautegui, & Zimmermann, 1994). Asians and Hispanics are the fastest growing groups among foreign-born population in the U.S., rising from 1.5 percent each in the early 1990s to 25 percent and 43 percent, respectively, in 1990 (Bureau of Census, 1993). Asian and Hispanic children, respectively, represent 3.5 percent and 14 percent of the U.S. elementary and secondary student enrollment in 1992, more than doubled from the 1.2 and 6.4 percents in 1976 (NCES, 1995).

Many developed nations share this challenge. The trend of globalization has brought rising waves of foreign labors, refugees, and immigrants into affluent countries. Today, the U.S., Canada, Australia, New Zealand, France, Germany, Britain, and other European countries are receiving newcomers from different regions of the world. The public schools in these countries confront the daunting task to educate children of immigrants.

Given the gravity of the issue, ironically, educators know little about the schooling of immigrant children. Little research has systematically dealt with the issue. It is unclear as to how the new generations of immigrants do in the school system and what their great diversity has to do with their schooling. It is even more uncertain about how schools are acting to help immigrant children learn math and science, subjects that are critical for competing in today's technology-oriented labor market. No baseline comparison is available regarding education of this group in the U.S. and other nations.

The lack of knowledge about immigrant children's education and general well being concerns educators and policymakers. The Federal Interagency Forum on Child and Family Statistics has published annual reports on children (Federal Interagency Forum on Child and Family Statistics, 1998). But the reports contain little information specifically about children of immigrant background. A recent study of immigrant children released by the National Research Council and the National Institute of Medicine points out that there is virtually no public dissemination of information on even the most basic indicators of the conditions of children in immigrant families (Hernandez & Carney, 1998). In a policy study report, the National Commission on Immigration Reform also calls for increased attention to and resources for immigrant children's schooling (see Schnaiberg, 1997). My study was intended to remedy this shortage of knowledge by comparing math and science performance of immigrant children in five English-speaking countries.

Literature Review and Research Questions

The available research on immigrant children's school performance is inconclusive even regarding the basic conditions of performance. Some studies suggest that the children of immigrants do better in school than the rest of American children; their performance is above averages (Rumbaut, 1996; also see Viadero, 1998, Lapin, 1998). In social adaptation, physical and mental health, foreign-born immigrant children were also seen to fare at least equally well as other children in the U.S. (Hernandez & Charney, 1998). On the other hand, there is evidence that immigrant children, especially Hispanics and others with impoverished background, suffer poor academic achievement

and lower educational attainment (e.g., McPartland, 1998; Vernez & Abrahamse, 1996). A foremost concern for research is to provide clear description of this population's schooling with solid baseline indicator of performance.

Aggregated comparisons may mask crucial variation within the immigrant population. For example, while Hispanic adolescents of all generations have grade point averages and math test scores that are lower than those of white adolescents in U.S.-born families (NCES, 1998a), academic achievement of immigrant students appears to *decline by generations* (Hernandez & Charney, 1998). The social, economic, and cultural factors that either protect or disadvantage immigrant children are not well understood. Thus, baseline indicators should also summarize performance differences by important subcategories of the immigrant children, such as generation of immigration, sex, native language, and socioeconomic status.

A small number of recent studies of immigrant children's academic achievement provide some insights for understanding the variation among immigrant children's academic achievement. For example, Hao and Bonstead-Bruns (1998) used the concept social capital to explain immigrant children's academic performance. This concept, though useful in understanding the behavioral and cultural attributes of immigrant groups affecting academic learning, is less relevant to study of the functioning of institutions, such as public schools. It is not clear from such research as to how schools could reduce the detriment caused by meager social capital for an immigrant child. Theories and research are needed to sort out institutional factors that account for the wide variation and the changing pattern of this population's academic performance. As a preliminary study intended to address some of these concerns, I examine the following issues in the analysis.

Generation Difference

The generation of immigration distinguishes a number of demographic characteristics among children from immigrant families. Compared with children in U.S.-born families, first-generation immigrant children (the foreign-born) are more likely to experience high poverty; to have a large family with both parents; and their parents are more likely to have attained little education yet to participate in labor force (Hernandez & Charney, 1988). Second-generation children (those born in the U.S. to at least one foreign- born parent) tend to experience substantially less risk than do first-generation children, but are likely to lose psychological resilience that the first generation often demonstrates. Such cross-generation distinctions imply different risks and strength for immigrant children's schooling.

The analysis first addresses the question about the performance gap relating to the generation of immigration in different countries. The second question is to what extent this gap differs across schools in each country. To answer this question, the analysis explores the variation of the generation gap across schools in each country. With the international test results available from the data, it should be particularly interesting to see how the school- level variation of the gap differs across countries. The resulting baseline indicator may reveal the extent to which the *overall* school setting relates to the variation of the gap—in contrast to the extent to which individual factors account for the variation. Future study may elucidate school roles in reducing the generation gap by examining specific school factors relating to the variation of the performance gap.

Language Barrier

Limited English proficiency handicaps immigrant children's learning on key subject areas such as mathematics and science. Language barriers are often more detrimental for children of low socioeconomic background. Living in socially and linguistically isolated communities, poor immigrant children can hardly improve their new language skills and the language barriers persist over the school years. On the other hand, bilingual proficiency, defined as the mastery of both the mother tongue and a new language, is found to be a strength for immigrant children's cognitive growth (e.g., Bumberger & Larson, 1998; Hao & Portes, 1998).

I first estimate the size of the math and science performance gaps related to non-English language background in each country. I then examine the variation of the gaps between schools in each country. While these baseline indicators are descriptive, they imply the extent to which the overall school context is associated with the variation of the gap-- relative to the individual level variation. The analysis may provide a ground for further study of specific school functions in reducing language-caused performance gap for immigrant children.

School Variation of Performance Gap

Does school has something to do with the performance gaps? It is conceivable that the average performance and the performance gap between immigrant children and the other children may vary across schools. Schools with different demographic composition, resources, and curricular and instructional programs theoretically could achieve different levels of excellence and equity. Relevant to policymaking, gauging such school-level variation is crucial for further assessing institutional role in achieving educational equity. Understanding the school-level variation in performance gaps and school features relating to such variation can help school improve equity. In this preliminary analysis I only examine the school-level variance in math achievement gap relating to the generation of immigration and language backgrounds.

Data Source

TIMSS is the most comprehensive and rigorous international education comparison ever (NCES, 1998b). I extracted TIMSS Population 1 (students of grades 3-4 or ages 8-9) data of five English-speaking countries including the U.S., Canada, England, Australia, and New Zealand, with unweighted samples size of, respectively, 10,670, 14,639, 5,584, 10,433, and 4,670. Conducted in 1995, TIMSS researchers tested the mathematics and science knowledge of more than half a million students in 41 countries at three grade levels—primary, middle, and end of secondary school. TIMSS ensured that the participating students in each country were representative of its population. It generated information on the background and math and science achievement tests for children of the participating countries. While tests on math and science were administered to students, survey data were collected from teachers, schools, as well as students. The resulting information encompasses student demographic background and math learning experience; teachers' background and instruction; and school facilities, program provisions, and demographic attributes. Information for identifying foreign-born children is available, including the nation of birth for both the parents and the child.

The TIMSS nationally representative sample designs generated data for the population of each target age group (or grade level) in a country. The sample for a given age group in a country was selected in a two-level stratified design. In this design, a

school sample representative to the national population of schools was drawn first, and within each selected school, typically one classroom at the target grade level was selected for the test and survey. While certain minority groups were oversampled, sample weights were provided to compensate the bias resulting from the oversampling. Unit nonresponse bias was corrected by sample weights as well.

The tests were designed through collaboration among experts from the participating countries. Recognizing vast differences in social and educational context, the tests were meant to measure students' general math and science knowledge and skills at the given age/grade. The results were widely accepted as valuable for cross-national comparison, given the caution of contextual differences among the participating nations (Forgione, 1998). Four items were used to identify students' immigrant background. They presented information about the child's birthplace (foreign- or native-born in one of the five countries), the number of years living in the current country, and the foreign-born status of the child's mother and father. I defined a child as a first-generation immigrant if the child was foreign- born regardless of the birthplace of the parents, and a second-generation immigrant if the child was born in the current country to one or both foreign-born parent; and the rest were considered as non-immigrants. With a data item about student home languages, I categorized students as a non-native language speaker if he or she reported that a language other than the TIMSS test language (English) was “often” or “always” spoken at home.

Analytical Methods

The analysis included two components. To generate baseline indicators of the overall performance patterns, I ran a series of descriptive analysis. To estimate school-level variance of performance gaps, I conducted two-level hierarchical linear modeling.

Descriptive Analysis

Descriptive analysis entailed comparing means of the test scores for the groups of interest. As specified earlier, baseline indicators of math and science performance gaps between immigrant and non-immigrant children will be estimated in a comparison of means with significance tests (all at the $p<.05$ level if not otherwise specified). All the remaining indicators will be generated by breaking down the test data by two categorical variables, immigrant status and non-English language background, with significance tests.

I ran the procedure with data for each country. The five plausible values for estimating performance on mathematics were used. The estimates from the five runs were then averaged as the final estimates in the comparisons (see TIMSS User's Guide for rationale for this special approach, International Study Center, 1988). Student-level sample weight (TOTWGT) was used to correct bias from unequal sampling of some student groups and unit nonresponse. I used jackknife procedures to correct the design effects caused by the stratified clustering sample design (rather than simple random design). See Chapters 5 and 7 of the User's Guide (International Study Center, 1998) for rationale of using sample weights and special procedures for correcting design effects.

HLM Procedure

To assess school-level variance of the performance gap relating to immigrant status, I used hierarchical linear modeling (HLM) technique (Bryk & Raudenbush, 1992). HLM was appropriate for this part of analysis because in the TIMSS design students as level-1 units were nested in schools (level 2) and HLM enabled me to separate the variance by two levels and to formally estimate the portion of variance taking place at school level.

In an unconditional (one-way ANOVA) with random effect model, I estimated variance separately at the student and school levels. This model answered the question as to whether schools differed from each other in average math performance. It provided basic estimates for making decision if it was necessary to further model the variance at the two levels. The unconditional models were:

At student level (level 1), $Y_{ij} = ß_{0j} + r_{ij}$ and

at school level (level 2), $ß_{0j} = µ_{00} + u_{0j}$.

As the school level variance was sufficiently large (10 percent or more of the total variance, measured with the intraclass correlation coefficient) for each country, I specified random coefficient models to estimate school-level variance of the math achievement mean and achievement gaps associated to home language and the first- and second generation immigrant backgrounds (all student-level predictor variables were centered around the school mean). At level 1, the equation had the overall achievement mean, the average achievement differences relating to the non-English language and immigrant status, and the random error,

$$Y_{ij} = ß_{0j} + ß_{1j}\,(\text{LANGUAGE}) + ß_{2j}\,(\text{FIRST\_G}) + ß_{3j}\,(\text{SECOND\_G}) + r_{ij}\,.$$

At level-2, the equations included no school variables but only the school average math score (the intercept) and the estimates of the variance around the average measures of the three gaps (the slope):

$$ß_{0j} = µ_{00} + u_{0j} \text{ and}$$

$$ß_{qj} = µ_{q0} + u_{qj} \text{ where } q=1, 2, 3.$$

In case the gaps did not vary statistically significantly at the school level, the random effect u_{qj} was removed from the equation and the effect was estimated only as fixed.

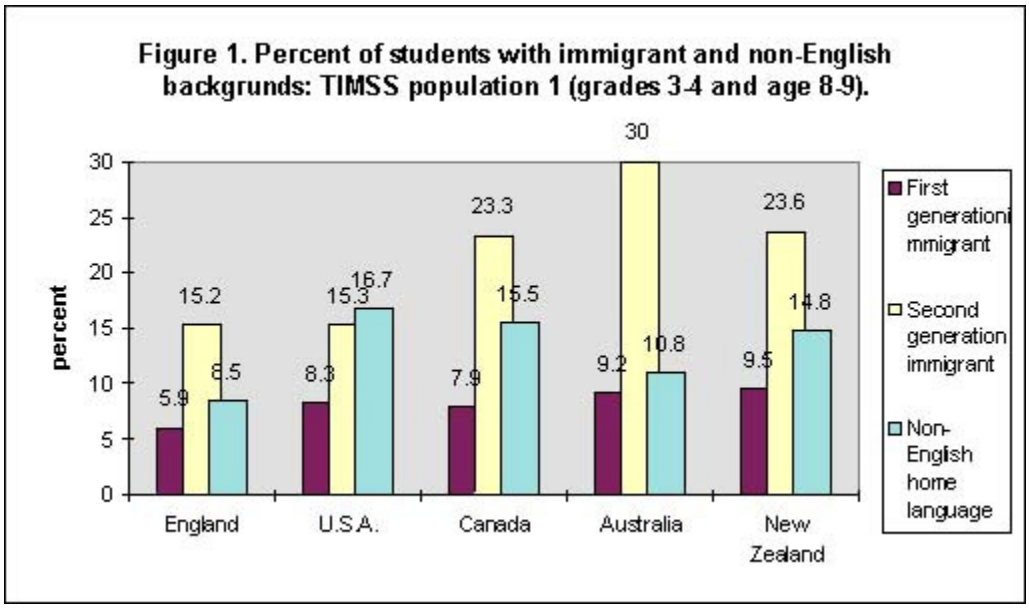
I used the software package HLM (version 4.03) for the analysis, running the Plausible Value procedure available from the package (Bryk, Raudenbush, & Congdon, 1996). This procedure included the five plausible values as the outcome variable and automatically averaged the resulting estimates after the runs. Normalized student level weight and school level weight were used in the procedures for generating the estimates to the student population in each country.

Findings

Students of Immigrant and Non-English Backgrounds

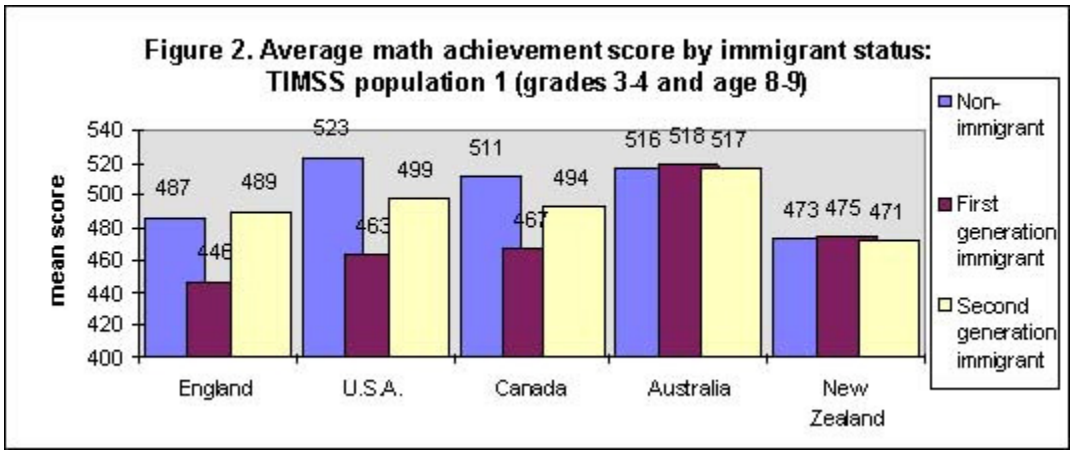
Each of the five countries' elementary student populations contained a substantial

portion of students with immigrant and non- English backgrounds (see Figure 1). Australia and New Zealand had the highest rates of immigrant students of both the first and second generations, followed by Canada and the U.S. Strikingly, the second generation immigrant children comprised almost one third of Australia's population of third and fourth graders. The U.S. had a relatively high proportion of children of non-English background (16.7 percent), though this group was fairly large in Canada and New Zealand as well.



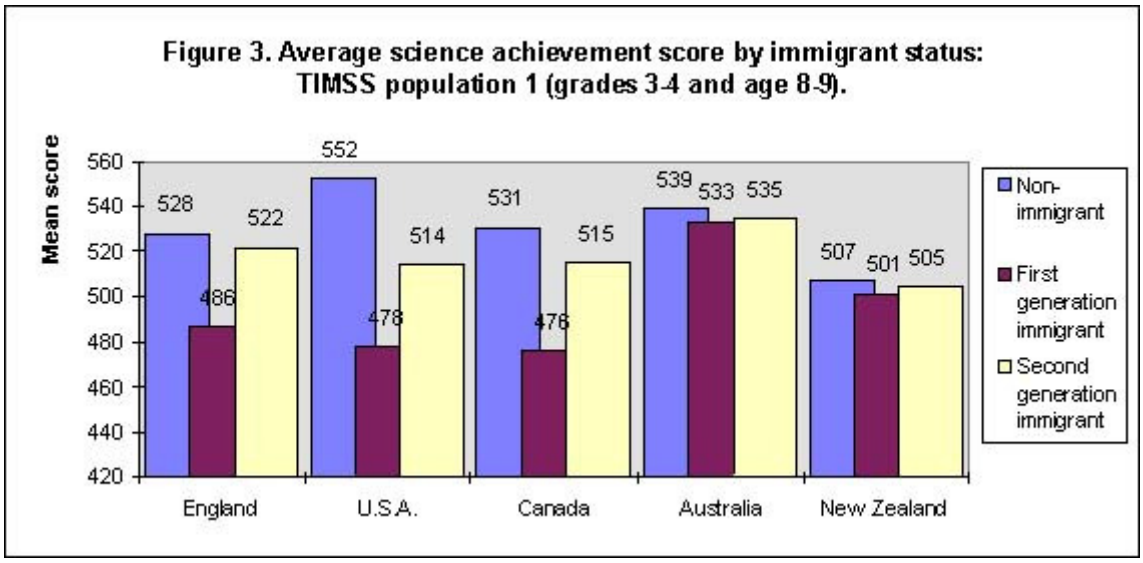
Performance Gaps Associated with Immigrant Status

The math achievement gaps to the disadvantage of immigrant students took place only in England, the U.S., and Canada, not in Australia and New Zealand. This pattern is particularly evident in the gap between non-immigrant and the first generation immigrant children (Figure 2). In England, the gap in math score was 41 point, in the U.S., 60, and in Canada, 44, all statistically significant; whereas in Australia and New Zealand, the gap was not observed. In the U.S. and Canada, the non-immigrant children scored higher than the second-generation immigrant children; but in England, this difference was not statistically significant.



The patterns of performance gaps associated with immigrant status were similar in

science (Figure 3). In short, immigrant students lagged behind in math and science learning in England, the U.S., and Canada, but they did not in Australia and New Zealand.



Immigrant and Language Background

Non-English home language is clearly a disadvantage to students' math and science learning regardless of immigrant status. In each group (non-immigrant and first and second generations of immigrant children), those whose home language was not English averaged substantially lower score than the rest of the students in math (Tables 1). Further, the language disadvantage was more acute among native-born children than among immigrant children. Consistent in each country, the second-generation immigrant children with non-English home languages did better in math than the non-immigrants with non-English home languages. I speculate that the latter was likely to be the indigenous groups or the groups that experienced persistent social and linguistic isolation, e.g., the American Indians and Hispanics in the U.S. Unfortunately, TIMSS contains no data to allow me confirm this assumption. With exception of the U.S. and Canada, this pattern holds between the first generation immigrant children and non-immigrants as well, though to a lesser extent.

Table 1
Average Math Achievement Scores by Immigrant Status and Home Language: TIMSS Population 1 (grades 3 or 4 and age 9 or 10) in the Five Countries

	England	U.S.A.	Canada	Australia	New Zealand
Non-immigrant	486.6	522.9	511.1	516.3	472.6
English	489.6	527.9	514.4	518.2	479.8
Non-English	419.2	472.2	470.5	436.2	407.7
First-generation Immigrant	446.2	462.9	466.5	517.9	474.7
English	452.4	475.5	476.2	534.8	491.9
Non-English	426.8	449.3	457.8	499.8	445.4
Second-generation immigrant	489.3	498.5	493.5	516.5	471.4
English	496.8	505.4	499.1	521.9	482.0
Non-English					

	464.9	486.5	477.9	489.7	427.4

Two-level Analysis

School level variance was substantial and statistically significant in all the five countries (Table 2). As indicated by the intraclass correlation coefficients, school-level variance proportional to the total variance around the given country's average math achievement ranged from 9 percent (Canada) to 26 percent (New Zealand). This finding suggests that to a considerable extent, students' math scores in each of the five countries tended to cluster around their school average scores. The reliability of the achievement measure was around 0.80, with exception of Canada, where the estimate was only 0.49. These baseline statistics justified further two-level modeling to examine the performance gaps relating to the language and immigrant status.

Table 2
Two-level unconditional models:
Baseline estimates from TIMSS Population 1 math achievement (plausible values average) in the five nations

Parameters	England	U.S.A.	Canada	Australia	New Zealand
Average school mean g_{00}	483.51	505.18	501.88	522.53	470.85
Reliability of the dependent variable	0.88	0.82	0.49	0.75	0.86
Intraclass correlation	0.19	0.18	0.09	0.16	0.26
School-level variance u_{oj}	1,700.63	1,755.81	1,349.94	1,864.95	2,102.65

Note: The school-level variance for each country was significant at p< 0.001 level.

Table 3 presents the estimates from the two-level random coefficient models. The first panel shows the fixed effects. The overall mean of each country (the intercept μ_{00}) provides a reference for interpreting the other estimates. First, non- English home languages were indeed a detrimental factor to children's math learning across the five nations. The large and negative coefficients consistently indicate that children with non-English home language background achieved lower than the overall mean in each country. The language barrier to math learning seems especially solid to students in England and the U.S.

The immigration status was a disadvantage only in some countries. Clearly, there was a negative relationship between the first generation of immigrants and the math achievement in England, the U.S., and Canada. But the relationship was reversed in Australia, where the first generation immigrant children achieved higher than the national average (a positive 13.4 at p<.01 level). There seems no relationship between the generation of immigration and achievement among New Zealanders as the two coefficients were small (2.42 and –5.46) and not statistically significant. The gap between the second generation of immigrants and the national average in general was narrower than that between their first generation counterpart and the national average. The second-generation children in England appeared to do slightly better than the

national average (a higher score of 8.42 at p<.05).

The estimates for random effects revealed how the above statistics varied at the school level. The language-related achievement gap varied among schools only in England; in other countries, this gap was rather stable across schools. The math achievement gap related to the first generation immigrant status did not vary across schools in any of the five countries. This finding implies that the problem of this group (or its strength in Australia) in math learning was regular across schools. Finally, the gap associated with the second generation of immigration in the U.S. varied substantially across schools, indicating that schools probably might have some thing to do with this group's performance. This gap also varied across schools in New Zealand, despite that the fixed estimate for the effect was nil (not statistically significant). This irony probably hints that the second-generation immigrant children performed quite differently in New Zealand pending on school environment, although the *average* difference at student level was not observed.

Table 3
Two-level random coefficient models:
Estimates for TIMSS Population 1 math achievement

Parameter	England	U.S.A.	Canada	Australia	New Zealand
Fixed effects: Student-Level Effects (Level-1 models)					
Intercept (overall mean achievement) μ00	482.47***	504.95***	501.86***	522.46***	470.85***
Non-English language difference μ10	-38.26***	-39.15***	-14.09***	-20.68***	-30.06***
First generation immigrant difference μ20	-21,87***	-26.95***	-44.75***	13.64**	2.42
Second generation immigrant difference μ30	8.42*	-4.25***	-12.21***	-7.61*	-5.46
Random effects: School-level variance (Level-2 models)					
School mean achievement, u0j	1710.05***	1783.27***	1352.19***	1868.44***	2087.59***
Non-English language difference, u1j	674.44*	—	—	—	—
First generation immigrant difference, u2j	—	—	—	—	—

Second generation immigrant difference, u2j	—	1076.18***	—	—	421.99**
Student level variance (Level-1 random effect), rij	7121.75	7387.03	13760.00	10017.03	5988.68

* p<.05; ** p<.01, *** p<.001
The symbol "—" indicates that the random variance was too small to model and thus the associated variable was specified only as a fixed effect in the model.
Note: All student-level predictor variables were centered on school means.

Summary

This analysis only touched on the surface of the immigrant children's academic learning in the five developed countries. It described the status of the group's math and science performance and help to settle the issue as to whether immigrant children achieve the same level as do non- immigrant children. In a cross-national comparison based on fairly comprehensive and reliable test information, the analysis indicated that in the U.S., England, and Canada, immigrant children--especially those known as the first generation of immigrants--did lag behind in math and science achievement. Further, non-English home languages, typically spoken by children of immigrants and indigenous people, were strongly and negatively related to lower math and science performance.

Considerable effort is needed to untangle the complicated issues surrounding the newcomers' schooling. For example, immigrants' socioeconomic status, family environments, gender role, and health conditions, could critically influence these children's math and science learning. Moreover, in academic subjects such as reading, writing, and social studies, where the language is either a pivotal tool of learning or simply the subject of study, we know even less about immigrant children's learning experience. Immigrant children's schooling and performance in those subject areas call for extended research.

The analysis also hints at the overall potential effect that schools might have in reducing the performance gaps associated with the immigrant and non-English backgrounds. The first-generation immigrant children's disadvantage (in the U.S., England, and Canada) and the strength (in Australia) in math performance seem consistent across schools in a given country. Does this finding suggest that schools can make little difference regarding immigrant children's learning? Maybe. However, it may also imply the overwhelming effect of immigrant socio-cultural conditions on their schooling and, possibly, the public education systems' uniform indifference to the group's needs.

To an extent differentiated by the countries, performance gaps associated with the second-generation immigrants and non-English home language varied among schools. This finding implies that schools could possibly make some difference in narrowing the gaps. Learning about specific school factors that may work to close the gaps requires further research. School factors such as socio-demographic attributes, resource allocation, special programs, staff training, and curriculum and instruction methods are subject to study if we are to understand the learning processes of the increasingly large group of immigrant children in public schools.

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The World Wide Web address for the *Education Policy Analysis Archives* is **epaa.asu.edu**

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