

Methodological Gap in Quantitative Analysis of Cross-Cultural Research Data

Wei Pan, University of Cincinnati
Haiyan Bai, University of Central Florida

Abstract

Demystifying the academic achievement gap between Asian American students and students of other groups has been an increasingly appealing topic in the literature on "model minority." However, previous quantitative analysis of cross-cultural research data are plagued by methodological problems such as use of invalid instruments, inappropriate significance levels, unrepresentative samples, and outdated databases. The present study provides updated quantitative evidence in explaining the academic achievement gap between Asian American students and students of other groups by conducting a multivariate analysis of variance and covariance on achievement test scores in mathematics and reading, using a cross-validated random sample drawn from an up-to-date national representative database.

Keywords: quantitative method, achievement gap, multivariate analysis

摘要

探討亞裔學生和其它種族學生之間的學業差距已成為有關少數民族成功典範研究中的熱門話題。然而在使用跨文化研究數據作數量化分析時，存在著一些方法學上的問題，例如無效工具、不恰當的顯著水平、無代表性樣本、和過時的數據庫。本文從具有全國代表性的最新數據庫中隨機抽取並經交叉驗證的樣本，對數學和閱讀的考試成績作多變項分析，從而為解釋亞裔學生和其它種族學生之間的學業差距提供了更新的數量化證據。

關鍵字: 量化方法, 成就差距, 多變項分析

Introduction

Demystifying the academic achievement gap that Asian American students score consistently higher on standardized tests than students of other groups has been an increasingly appealing topic in the literature on "model minority" (Hsia & Peng, 1998; Sue & Okazaki, 1990; Wong & Halgin, 2006). However, as pointed out by Wang (2006), there are some methodological problems among quantitative studies, such as use of invalid instruments (e.g., Kuhn, 2006)

and unrepresentative samples (e.g., Toupin & Son, 1991). To address these methodological issues, some quantitative studies (e.g., Goyette & Xie, 1999; Kao, 1995; Mau, 1997; Sun, 1998; Xie & Goyette, 2003) have utilized the database of the National Educational Longitudinal Study of 1988 (NELS:1988) (Curtin, Ingels, Wu, & Heuer, 2002) because it provides rich and valid educational data on national representative samples. Results from these studies suggest that socioeconomic status (SES), parents' and student's attitudes and actions related to schoolwork, parents' and student's expectations, parental involvement, family composition, home resources, and peer influence are significant factors to explain the achievement gap between Asian American students and students of other groups.

Although these studies address the model minority issue, none of these studies conducted cross-validation for their research results, raising a concern about the validity of their conclusions. Another methodological issue is Type I error inflation. The significance level $\alpha = .05$ designated by previous researchers is inappropriate for the large sample sizes ranging from 13,000 to 23,000. Instead, an alpha level lower than .05 should be used for such a large sample to prevent Type I error inflation. Alternatively, a smaller random sample could be selected at the .05-alpha level and achieve an optimal statistical power (Cohen, 1988). Moreover, inferential results based on data collected from more than fourteen years prior may not be as representative of the economy, lifestyle, and cultural values of current times. For example, the median household income increased from \$32,190 (\$40,678 in 2003 adjusted dollars) in 1988 to \$43,381 (in 2003 adjusted dollars) in 2002 (DeNavas-Walt, Proctor, & Mills, 2004); and the percent of children under 18 years old who live with adults other than their parents increased from 27% in 1988 to 31% in 2002 (U.S. Census Bureau, 2006). As a result, the aforementioned factors may not be adequate to describe the current social context. These problems have led to a methodological gap in quantitative analysis of cross-cultural research data on academic achievement among different ethnic groups, and therefore, threatening the validity of existing studies.

The purpose of this study is to provide updated quantitative evidence from a cross-validated random sample in explaining the academic achievement gap between Asian American students and students of other groups by conducting a multivariate analysis of variance and covariance on achievement test scores in mathematics and reading. The data for this present study come from a random sample of students drawn from the national Educational Longitudinal Study of 2002 (ELS:2002) (National Center for Education Statistics, 2004). The random sample is cross-validated by another random sample drawn from the same database. The sample sizes of the two random samples are determined with consideration of optimal statistical power (Cohen, 1988) for detecting a medium effect size at a significance level $\alpha = .05$.

A bibliographical search compiled by the National Center for Education Statistics (2005) shows that few published journal articles utilized the ELS:2002. The present study contributes to the literature with updated quantitative evidence in explaining the academic achievement gap between Asian American students and students of other groups.

Method

Data and Participants

The ELS:2002 base-year survey was conducted in 2002 on 15,362 tenth grade students randomly selected from 752 schools across the U.S. The *primary sample* for this present study includes 6,125 students after missing data treatment (Allison, 2001; Little & Rubin, 1987). To achieve the optimal statistical power with a significant level $\alpha = .05$, a 20 percent random sample, or *study sample*, with 1,154 students is drawn from the primary sample for analysis in this present study. In order to cross-validate statistical results from the study sample, another 20 percent random sample, the *validation sample*, with 1,247 students is drawn from the same primary sample for the purpose of cross-validation.

Constructs and Variables

Besides *academic achievement*, which is measured by achievement test scores in mathematics and reading, other constructs investigated in this present study are (a) *sociodemographic background*, which is measured by socioeconomic status, family composition, gender, and English as a native language; (b) *family educational support system*, which is measured by parents' expectation, parental involvement in schoolwork, communication with parents, parental limitations, and home resources; (c) *psychological and behavior*

factors, which is measured by student's expectation, life values of work and family, study effort, importance of good grades, self-confidence in mathematics and reading, frequency of watching television/video and playing video/computer games, and frequency of computer use for things other than gaming; and (d) *study and school experiences*, which is measured by hours per week spent on mathematics and English homework, frequency of cutting or skipping classes and getting in trouble, frequency of book use besides mathematics textbooks, hours per week spent on reading outside of school, reasons for going to school, feeling good about school and teachers, and school safety. Some of the aforementioned variables have been used in past research (Chao, 2001; Desimone, 1999; Fan, Chen, & Matsumoto, 1997; Fejgin, 1995; Goyette & Xie, 1999; Kao, 1995; Mau, 1997; Pong, Hao, & Gardner, 2005; Sun, 1998; Wong, Lai, Nagasawa, & Lin, 1998; Xie & Goyette, 2003; Yeh, Carter, & Pieterse, 2004); while the selection of other new variables for the present study is guided by these studies (Du, Havard, Yu, & Adams, 2004; Scott, 2004).

Statistical Analysis

Analysis in the present study is sequentially conducted through four models of multivariate analysis of variance and covariance (MANOVA/MANCOVA) to explain the academic achievement gap between Asian American students and students of other groups. Model 1, or the *Asian model*, estimates the *gross gap* in academic achievement without controlling for any factors or covariates. Subsequent models investigate factors known to contribute to the achievement gap.

For a comparison purpose, Model 2, or the *old model*, is conducted to obtain the adjusted achievement gap between Asian American students and other students after controlling for factors that have been explored in past literature on Asian American students. Model 2 replicates prior research and serves as a means of investigating the methodological gap in analysis of cross-cultural data on academic achievement among students of different ethnic groups. In Model 3, or the *full model*, new factors are added on top of the factors controlled in Model 2. Model 3 provides a better estimate of the academic achievement gap between Asian American students and students in other groups, as the additional factors more accurately reflect the contemporary social context. Model 4 is a *parsimonious model* that includes only significant factors and excludes insignificant ones. It provides valid and updated quantitative evidence in explaining the academic achievement gap between Asian American students and students in other

groups in the current study.

Results

Descriptive Analysis

Among the 1,154 students in the study sample, there are 80 (7%) Asian American students and 1,074 (93%) students in other groups; 617 (53%) female students and 537 (47%) male students; and 1,007 (87%) students who had English as their native language and 147 (13%) students who did not. The average achievement test scores in mathematics and reading are 53.88 ($SD = 9.33$) and 53.75 ($SD = 9.58$) for the total study sample; 57.03 ($SD = 10.52$) and 53.83 ($SD = 9.03$) for Asian American students; and 53.64 ($SD = 9.20$) and 53.74 ($SD = 9.62$) for students in other ethnic groups.

An equivalence analysis of the study sample shows that besides the striking difference in the percent of students whose native language was English (34% vs. 91%, $p < .001$), Asian American students as compared to students in other ethnic groups had statistically significant disadvantages on the following variables: family composition ($p < .05$), parental involvement in homework ($p < .01$), home resources in library ($p < .01$), home resources in house wares ($p < .001$), and school safety ($p < .01$). However, Asian Americans as compared to students of other ethnic groups were statistically significantly better on these variables: parents' expectation ($p < .001$), parental limitations ($p < .05$), home resources in technology ($p < .05$), student's expectation ($p < .001$), study effort ($p < .01$),

importance of good grades to student ($p < .001$), self-confidence in math ($p < .05$), frequency of computer use for things other than gaming ($p < .001$), and reasons for going to school ($p < .001$).

The statistical analysis in the present study focuses on a multivariate analysis of variance (MANOVA) and covariance (MANCOVA) on mathematics and reading altogether, rather than separate univariate analyses on mathematics and reading.

MANOVA/MANCOVA

Model 1 (Asian Model). Table 1 displays results of the multivariate F -test for the Wilk's Λ across all four MANOVA/MANCOVA models. As seen in the table, Model 1 shows that the gross gap in academic achievement between Asian American students and students of other groups is significant ($p < .001$). Subsequent models would disentangle this achievement gap by controlling for different factors.

Model 2 (Old Model). As we can see under Model 2 in Table 1, factors such as family composition, parental limitations, life values of work and family, importance of grades to student and his/her friends, and hours per week spent on mathematics homework, are not significant in the present study. In addition, home resource is either not significant or only marginally significant. These nonsignificant findings might have been a result of social change, inappropriate significance level, or both.

Table 1.

Multivariate Analysis of Mathematics and Reading Achievement (N = 1,154)

Constructs/Variables	Model 1	Model 2	Model 3	Model 4
	F	F	F	F
<i>Sociodemographic Background</i>				
Asian	10.49***	8.33 ***	8.20 ***	8.91 ***
Socio-economic status		39.66***	25.57***	38.01 ***
Family composition		1.05	.88	
Gender			11.22***	13.97***
English as a native language			7.38 ***	8.64 ***
<i>Family Educational Support System</i>				
Parents' expectation		19.62***	14.28***	17.65***
Parental involvement in schoolwork		19.25***	14.96***	11.92***
Communication with parents		7.23 ***	4.98 **	8.22 ***
Parental limitations		1.85	2.34	
Home resources in technology		3.09 *	.60	
Home resources in library		2.38	1.33	
Home resources in house ware		3.60 *	1.99	

* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 1 – cont.

Multivariate Analysis of Mathematics and Reading Achievement (N = 1,154)

Constructs/Variables	Model 1	Model 2	Model 3	Model 4
	F	F	F	F
<i>Psychological and Behavior Factors</i>				
Student's expectation		17.25***	12.86***	12.07***
Life values of work		2.39	1.95	
Life values of family		1.23	1.35	
Study effort		4.52 *	6.26 **	6.17 **
Importance of good grades to student		.05	2.00	
Importance of grades to friends		1.05	.34	
Self-confidence in Math			53.18***	53.57***
Self-confidence in Reading			26.15***	26.38***
Frequency of watching TV/DVD & playing video/computer games			7.01 ***	8.20 ***
Frequency of computer use for things other than gaming			3.96 *	5.81 **
<i>Study and School Experiences</i>				
Hours/week spent on math homework		.09	1.17	
Hours/week spent on English homework		3.72 *	2.05	
Frequency of cutting/skipping classes and getting trouble		6.96 ***	4.37 *	5.57 **
Frequency of book use besides math textbooks			22.56***	24.01***
Hours/week spent on reading outside of school			9.85 ***	9.45 ***
Reasons for going to school			14.48***	15.17***
Feeling good about school and teachers			5.26 **	5.33 **
School Safety			5.34 **	4.49 *

* $p < .05$. ** $p < .01$. *** $p < .001$.

Interpretation of significant factors in Model 2 suggests that Asian American students had higher values than students of other groups on some favorable factors, such as parents' and student's expectations and study effort, which in turn positively related to achievement test scores ($r = .41, .42, \text{ and } .22$, respectively). When these favorable factors are controlled for in the model, the academic achievement gap between Asian American students

and students of other groups are narrowed (cf., Figure 1). However, Model 2 ignores other important factors of the academic achievement gap between Asian American students and students of other groups, such as English as a native language, self-confidence in mathematics and reading, reasons for going to school. These new factors are included in Model 3 and 4, which are described below.

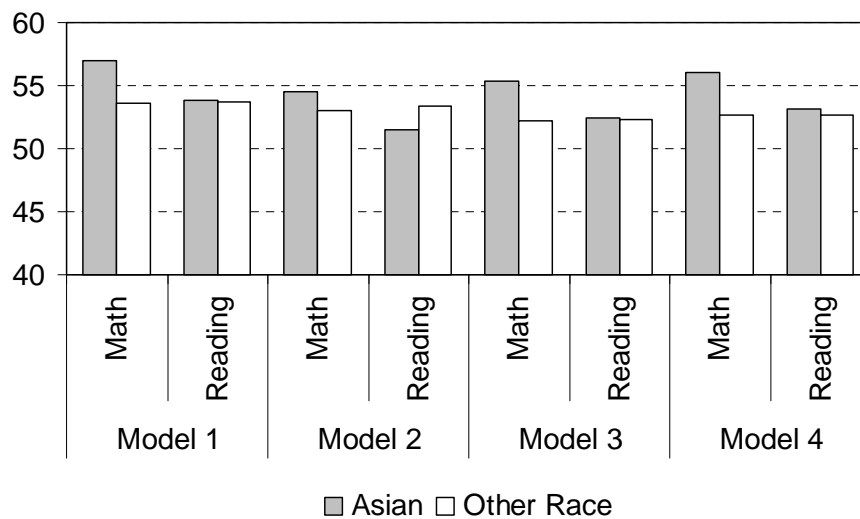


Figure 1. The estimated means of the achievement test scores from MANOVA/MANCOVA.

Model 3 (Full Model). Besides the factors included in Model 2, Model 3 includes several important new factors that reflect the contemporary social context in demonstrating the significant difference in explaining the academic achievement gap between Asian American students and students of other groups. The significance pattern of repeated factors in Model 3 is similar to that of Model 2, while all new factors are significant at $\alpha = .05$ level.

Model 4 (Parsimonious Model). Model 4 is parsimonious after removing all nonsignificant factors from Model 3, providing valid and updated quantitative evidence in explaining the academic achievement gap between Asian American students and students of other groups in the current study. Results from Model 4 reveals that the estimated achievement gap between Asian American students and students of other groups is significant ($p < .001$) (cf. Figure 1) after controlling for all significant factors, including both factors that are favorable to Asian American students and factors that are not. The favorable factors, such as parents' and student's expectations, study effort, self-confidence in mathematics and reading, frequency of computer use for things other than gaming, frequency of book use besides mathematics textbooks, hours per week spent on reading outside of school, and reasons for going to school, narrowed the achievement gap between Asian American students and students of other groups after they are controlled for. The unfavorable factors, such as socioeconomic status, English as native language, parental involvement in homework, communication with parents, and school safety, widened the achievement gap after they are controlled for.

Cross-Validation

All of the MANOVA/MANCOVA analyses above have been conducted based on the study sample that was randomly drawn from the primary sample. In order to substantiate the validity and stability of the statistical results from the study sample, a cross-validation has been carried out on the validation sample with 1,247 students randomly drawn from the same primary sample. A comparison of results between the study sample and the validation sample shows that the estimates and the significance patterns are similar across the two random samples. Therefore, results from the study sample corroborates with results from the validation sample.

Discussion

The present study investigates the methodological gap in quantitative analysis of cross-cultural research data used to explain the academic achievement gap between Asian American students and students of other groups. Results from the sequential MANOVA/MANCOVA employed in the present study suggest that changes in the pattern of statistical significance among factors explored in earlier studies could be attributable to change in social context, inappropriate significance level, or both. The current study uses data from the ELS:2002, the most recent national representative database. Furthermore, findings from the current study have been cross-validated with results conducted on another sample randomly selected from ELS:2002.

Findings from the current study suggest future directions for students of other ethnic groups to close the academic achievement gap. The achievement gap is evident between Asian American students and students of other groups both before and after controlling for other factors. Model 1 provides empirical evidence for the significant *gross gap* ($p < .001$) in academic achievement without controlling for other factors; and Model 4 provides empirical evidence of the significant *net gap* ($p < .001$) in academic achievement after controlling for other factors. Among these controlled factors, some of them are more favorable to Asian American students than to students of other groups, and others are not. When the favorable factors are controlled for, the achievement gap between Asian American students and students of other groups is narrowed. This study found that parents' and student's expectations, study effort, self-confidence in mathematics and reading, frequency of computer use for things other than gaming, frequency of book use besides mathematics textbooks, hours per week spent on reading outside of school, and reasons for going to school are favorable factors.

It is worth noting that statistical analysis conducted in the present study is based on the assumption that relationships among variables are linear. In the real world, some relationships might be nonlinear; therefore, future analysis might investigate both linear and nonlinear relationships. In addition, future studies might consider using more advanced methodology, such as structural equation modeling, to better understand the complex casual relationships among individual differences and academic achievement gap among different ethnic groups.

References

- Allison, P. D. (2001). *Missing data*. Thousand Oaks, CA: Sage.
- Chao, R. K. (2001). Extending research on the consequences of parenting style for Chinese Americans and European Americans. *Child Development, 72*(6), 1832-1843.
- Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.
- Curtin, T. R., Ingels, S. J., Wu, S., & Heuer, R. (2002). *National education longitudinal study of 1988: Base-year to fourth follow-up data file user's manual* (NCES 2002-323). Washington, DC: U.S. Department of Education, National Center for Education Statistics.
- DeNavas-Walt, C., Proctor, B. D., & Mills, R. J. (2004). *Income, poverty, and health insurance coverage in the United States: 2003*, U.S. Census Bureau, Current Population Reports, (P60-226). Washington, DC: U.S. Government Printing Office.
- Desimone, L. (1999). Linking parental involvement with student achievement: Do race and income matter? *Journal of Educational Research, 93*, 11-30.
- Du, J., Havard, B., Yu, C., & Adams, J. (2004). The impact of technology use on low-income and minority students' academic achievement: Educational longitudinal study of 2002. *Journal of Educational Research & Policy Studies, 4*, 21-38.
- Fan, X., Chen, M., & Matsumoto, A. R. (1997). Gender differences in mathematics achievement: Findings from the national education longitudinal study of 1988. *Journal of Experimental Education, 65*, 229-242.
- Fejgin, N. (1995). Factors contributing to the academic excellence of American Jewish and Asian students. *Sociology of Education, 68*, 18-30.
- Goyette, K., & Xie, Y. (1999). Educational expectations of Asian American youths: Determinants and ethnic difference. *Sociology of Education, 72*, 22-36.
- Hsia, J., & Peng, S. S. (1998). Academic achievement and performance. In L. C. Lee & N. W. S. Zane (Eds.), *Handbook of Asian American psychology* (pp. 325-358). Thousand Oaks, CA: Sage.
- Kao, G. (1995). Asian Americans as model minorities?: A look at their academic performance. *American Journal of Education, 103*, 121-159.
- Kuhn, D. (2006, March 8). Does the Asian success formula have a downside? *Education Week*, March 8, 29.
- Little, R. J. A., & Rubin, D. B. (1987). *Statistical analysis with missing data*. New York: Wiley.
- Mau, W.-C. (1997). Parental influences on the high school students' academic achievement: A comparison of Asian immigrants, Asian Americans, and White Americans. *Psychology in the Schools, 34*, 267-277.
- National Center for Education Statistics. (2004). *Education longitudinal study of 2002: Base year data file user's manual*, NCES 2004.405, by Steven J. Ingels, Daniel J. Pratt, James E. Rogers, Peter H. Siegel, and Ellen S. Stutts. Project Officer: Jeffrey A. Owings. Washington, DC: U.S. Department of Education, National Center for Education Statistics.
- National Center for Education Statistics. (2005). *ELS:2002 annotated bibliography*. Washington, DC: U.S. Department of Education, National Center for Education Statistics.
- Pong, S.-L., Hao, L., & Gardner, E. (2005). The roles of parenting styles and social capital in the school performance of immigrant Asian and Hispanic adolescents. *Social Science Quarterly, 86*(4), 928-950.
- Scott, L. A. (2004, April). *Two new themes: Motivational scales and computer technology items in ELS:2002*. Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.
- Sue, S., & Okazaki, S. (1990). Asian-American educational achievements. *American Psychologist, 45*, 913-920.
- Sun, Y. (1998). The academic success of East-Asian-American students—An investment model. *Social Science Research, 27*, 432-456.
- Toupin, E. S. W., & Son, L. (1991). Preliminary findings on Asian Americans: The model minority in a small private east coast college. *Journal of Cross-Cultural Psychology, 22*, 403-417.
- U.S. Census Bureau. (2006). *Living arrangements of children under 18 years old: 1960 to present*. Washington, DC: U.S. Census Bureau. Retrieved July 25, 2006 from <http://www.census.gov/population/socdemo/hh-fam/ch1.pdf>.
- Wang, L. S. (2006, March 29). 'Asian downside' study: Take with a grain of salt. *Education Week*, p. 42.
- Wong, F., & Halgin, R. (2006). The "model minority": Bane or blessing for Asian Americans? *Journal of Multicultural Counseling and Development, 34*, 38-49.
- Wong, P., Lai, C. F., Nagasawa, R., & Lin, T. (1998). Asian American as a model minority: Self-perceptions and perceptions by students of other groups. *Sociological Perspectives, 41*, 95-118.
- Xie, Y., & Goyette, K. (2003). Social mobility and the educational choices of Asian Americans. *Social Science Research, 32*, 467-498.
- Yeh, C., Carter, R. T., & Pieterse, A. L. (2004). Cultural values and racial identity attitudes among Asian American Students: An exploratory investigation. *Counseling and Values, 48*, 82-95.

Author

Dr. Wei Pan is an Assistant Professor of Quantitative Educational Research in Educational Studies and Leadership at University of Cincinnati. Dr. Pan's research interests are quantitative research methodology, causal inference, hierarchical linear models, structural equation modeling, meta-analysis, and their applications in educational and behavioral sciences.

Dr. Haiyan Bai is an Assistant Professor of Quantitative Research Methodology in the Department of Educational Research, Technology and Leadership at University of Central Florida. Her research interests are re-sampling methods, measurement, assessment, research designs, multivariate statistics, hierarchical linear modeling, structural equation modeling, meta-analysis, and their applications in educational research and the behavioral sciences.