Abstract Title Page
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Title:
The Futility of Propensity Score Methods in a Statewide Study of International Baccalaureate (IB)

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Abstract Body

Limit 4 pages single-spaced.

Background / Context:

Description of prior research and its intellectual context.

With the goal of increasing students' academic readiness for college, high schools in the United States are increasingly offering "credit-based transition programs," including International Baccalaureate (IB), Advanced Placement (AP), and dual enrollment. In 2003, most public high schools in the nation offered at least one credit-based transition program, with 2% of high schools offering IB, 67% offering AP, and 71% offering dual enrollment (Waits, Stezer, & Lewis, 2005). Although not as prevalent as AP or Dual Enrollment, the IB Diploma Program may be the most rigorous credit-based transition program of the three.

Existing research points to the promise of IB, AP, and other credit-based transition programs for improving students' academic readiness for college (e.g., Duevel, 1999; Foust et al., 2009; Poelzer & Feldhusen, 1996; Moydell et al., 1991; Roderick, Nagoaka, Coca, & Moeller, 2009; Saavedra, 2011); however, conclusions about program effects are often limited by potential issues of selection bias. More specifically, most research is limited by selection bias at the school and student levels. Despite strong statistical controls and assumptions to address selection, observational research may not be able to determine whether differences in outcomes are caused by program participation or are simply an artifact of the unmeasured characteristics of schools, students, and families that correlate with the decision to participate in these optional programs.

Purpose / Objective / Research Question / Focus of Study:

Description of the focus of the research.

To address this knowledge gap and inform future studies of the impacts of IB and other credit-based transition programs, this paper makes three contributions. First, a review of existing literature is used to produce an empirically-based conceptual model of selection into IB. Second, the conceptual model is used to identify the characteristics of students and schools that participate in the IB Diploma Programme using data from the National Center for Education Statistics and the Florida Education Data Warehouse. The conceptual model also allows us to identify key predictors for which there are no data available. Third, we test the ability of the available data to adjust for observed selection bias using propensity score methods (Rosenbaum & Rubin, 1983), with the degree of bias reduction reported for each predictor. If substantial selection bias persists after the adjustments, or if the adjustments impose dramatic extrapolations of the data (i.e., comparing apples and oranges), then we must question the utility and validity of propensity score analyses intended to estimate the causal impacts of this type of program on students' academic and college-related outcomes.

Figure 1 illustrates the conceptual model guiding the analyses in this study. This conceptual model is derived from research on IB and other credit-based transition programs and presumes that a student's decision to enroll in IB is influenced by characteristics of individual students, their families, and the schools they attend. At the student level, participation in IB is expected to correlate with demographic characteristics including gender, race/ethnicity, socioeconomic status, country of birth, and primary language spoken at home (Bailey & Karp, 2003; Chen, Wu, & Tasoff, 2010; Estacion et al., 2011; Klopfenstein, 2004; Perna et al., 2013;

Perna, 2004; Saavedra, 2011). Additional family influences such as parents' education, expectations, involvement, and knowledge have been shown to play important roles in selection of IB students (Attewell & Domina, 2008; Bailey & Karp, 2003; Chen, Wu, & Tasoff, 2010; Perna et al., 2013). Research also confirms that participation in IB is related to students' academic characteristics including English-language proficiency, participation in gifted and talented programs, participation in special education, attendance rate, prior grades, prior test scores, and prior success in advanced courses (Bailey & Karp, 2003; Chen, Wu, & Tasoff, 2010; College Board, 2011; Estacion et al., 2011; Florida Legislature, 2009; Perna et al., 2013; Saavedra, 2011). At the school-level, such characteristics as urbanicity, poverty, racial diversity, magnet/charter status, school size, school performance, teacher characteristics, college attendance rate, and school finances are shown to predict IB-participation (Barbour & Mulcahy, 2006; Byrd, 2007; Coca et al., 2012; Irvin, Hannum, Farmer, de la Varre, & Keane, 2009; Karp, Bailey, Hughes, & Fermin, 2004; Iatarola et al., 2011; Lerner & Brand, 2008; OPPAGA, 2009; Strange, Johnson, Showalter & Klein, 2012; Waits et al., 2005). Lastly, through eligibility criteria and recruitment activities, student and school characteristics work together to influence a student's opportunity to participate in IB (Estacion et al., 2011; Godfrey, 2009; Hertberg-Davis and Callahan, 2008; Perna et al., 2013; Siskin et al., 2010). This conceptual model of selection into IB allows us to not only recognize the important factors that differentiate IB students and schools from non-IB students and schools, but also to evaluate the extent to which the data available address or ignore aspects of the selection process.

Setting:
Description of the research location.
(May not be applicable for Methods submissions)

The state of Florida, including longitudinal data for 6 cohorts of high school students from 2002-2007.

Population / Participants / Subjects:
Description of the participants in the study: who, how many, key features, or characteristics.

The data used in this study come from the Florida K-20 Education Data Warehouse (FL-EDW) and the U.S. Department of Education's Common Core of Data (CCD). Our subset of data from FL-EDW has student-level records for 20,373 students who participated in an IB Diploma Programme and graduated between 2002 and 2007, and student-level records for 86,008 randomly sampled students who did not participate in an IB Diploma Programme and graduated over the same time period.

Intervention / Program / Practice:
Description of the intervention, program, or practice, including details of administration and duration.
(May not be applicable for Methods submissions)

IB Diploma Programme students are expected to enroll full-time in the two-year program in 11th and 12th grades and take courses in each of six subject groups (i.e., language, second language, individuals and societies, experimental sciences, mathematics and computer science, the arts). At least three of these courses must be taken at the higher level, while the other courses may be taken at the standard level. Higher-level courses represent approximately 240 teaching

hours and standard level courses represent approximately 150 teaching hours. To earn an IB Diploma, candidates must pass the internationally standardized IB exam. Also, they must satisfy the three compulsory components of the IB Diploma Programme: Theory of Knowledge; Extended Essay; and Creativity,Action, Service. IB students who do not fulfill all of the requirements for an IB Diploma may earn an IB Certificate instead. Approximately 80% of participating students earn the IB Diploma (IB Americas, 2011).

Significance / Novelty of study:
Description of what is missing in previous work and the contribution the study makes.

Most studies that employ propensity score methods do not include a logic model for the selection process and the variables included in the propensity score model are simply those that happened to be available. This study shows that when the selection process is adequately modeled, propensity score methods may simply confirm that causal inference is not supported.

Statistical, Measurement, or Econometric Model:
Description of the proposed new methods or novel applications of existing methods.

Our analyses examine the selection mechanisms behind IB participation across Florida, the state with the second highest representation of IB programs in the nation. We utilize longitudinal student and school-level data to address the following research questions:

1. What are the student- and school-level predictors of participating in the IB Diploma Programme in Florida?
2. To what degree does propensity score stratification or matching reduce selection bias associated with key student and school-level factors, thus supporting (or not) causal inferences about the impacts of IB on later student outcomes?

Usefulness / Applicability of Method:
Demonstration of the usefulness of the proposed methods using hypothetical or real data.

Propensity score methods have become very popular in non-experimental studies of program impacts. This study demonstrates the limited applicability of propensity score methods when the selection process is well-defined and most elements are measured and controlled—the propensity scores in this situation may simply show that causal inference is not appropriate.

Research Design:
Description of the research design.

We use various propensity score modeling strategies as a means to construct a suitable comparison group for IB Participants. The success of each strategy in creating a comparable group is assessed using descriptive and multivariate analyses.

Data Collection and Analysis:
Description of the methods for collecting and analyzing data.

Our data include longitudinal student-level data from elementary school through high school (i.e., 3rd through 12th grades) on student demographics, participation in school programs

(e.g., special education, gifted, free/reduced lunch), attendance, promotion/retention, grade point average, state achievement test scores (i.e., FCAT scores), course-taking patterns in high school, SAT and ACT scores, and postsecondary enrollment data. A total of 635 different high schools are represented by one or more students in this sample. The school-level data from the CCD include school type (e.g., regular, alternative, magnet, charter), locale, Title I eligibility, pupil/teacher ratio, student demographics (i.e., by race and free/reduced lunch eligibility), and school size.

Our analytic methods for addressing the research questions involved five stages. In the first stage, we used multiple imputation to address missing data problems (although nearly all variables were missing less than 5% of their data). In the second stage, we estimated bivariate relationships between IB participation and individual student and school-level variables measured prior to enrollment in IB, beginning as early as 3rd grade. In the third stage, we estimated a hierarchical multivariate logistic regression predicting IB participation based on the full set of available student and school-level variables. The fourth stage used the predicted values from the third stage as propensity scores and assessed comparability of IB students to other students in the state on measures taken prior to 11th grade. These analyses assessed the ability of propensity score stratification and matching (optimal pair matching and optimal full matching) to reduce selection bias. The fifth stage used the propensity scores and matching results to estimate adjusted differences in key outcomes between IB and non-IB students.

Findings / Results:

Description of the main findings with specific details.

Our results revealed that, when looking at the statewide population in Florida, the selection bias associated with voluntary participation in IB is very large (see Tables 1-4). The strongest predictor of IB participation among the individual demographic variables was gifted/talented status, with IB students more than 6 times as likely to be gifted compared to non-IB students. Among the academic performance indicators, the strongest predictors were course-taking patterns in 9th and 10th grades. Students who took Algebra I early (i.e., before 9th grade) were 23 times more likely to participate in IB, while students who took Algebra I late (i.e., after 9th grade) were 25 times less likely to participate. Students who took more advanced courses (i.e., honors, AP) in 9th and 10th grades were 18 to 43 times more likely to participate in IB. A number of school-level variables were predictive of IB participation, but these relationships were generally much weaker than student-level factors.

The predictive power of the multivariate propensity score models was incredibly high, with concordance indices ranging from 99.2% to 99.5%. These high concordance indices suggest that the propensity score models are able to correctly distinguish IB and non-IB students more than 99% of the time (see Table 5). Figure 2 shows density plots of propensity scores by graduation cohort. In each of these plots, one thing is very clear—there is little overlap in the distribution of estimated propensity scores between IB students and non-IB students. The propensity scores for IB students are heavily left-skewed, while the propensity scores for the non-IB students are even more heavily right-skewed. The vast majority of IB students' propensity scores are lumped mostly at the high end (i.e., between .80 and 1.0), while the propensity scores for the non-IB students are lumped mostly at the low end (i.e., between 0.0 and .10) (see Table 6).

Results from the propensity score stratification and matching stages (see Tables 6-14) revealed that even though the propensity score adjustments seemed to reduce the selection bias for most variables to a non-significant level, the lack of overlap in the propensity scores meant that our models were reliant on conditional comparisons in which thousands of IB students are compared to only a couple hundred non-IB students (i.e., at the higher end of the propensity score distribution) and thousands of non-IB students are compared to only a few hundred IB students (i.e., at the lower end of the propensity score distribution). Consequently, the ability of our models to produce unbiased estimates of impacts on student outcomes (see Tables 15-17) using these propensity scores is likely quite poor, with the most critical regions of the model (e.g., outcomes for non-IB students who are similar to IB students, and vice versa) based on only a tiny fraction of the available sample.

Conclusions:

Description of conclusions, recommendations, and limitations based on findings.

This study revealed that, when looking at the statewide population in Florida, the selection bias associated with voluntary participation in IB is very large, and that mechanisms for dealing with selection bias using propensity scores may not be sufficient. In other words, comparing IB and non-IB students in this statewide context is like comparing apples and oranges, and using propensity score methods to adjust for these differences require strong assumptions and extrapolation into regions with very thin data.

A major implication of this work is that a comprehensive logic model of the selection mechanism is essential for any observational study. In our study of IB, we found that the strongest predictors of participation were not the indicators most commonly used to address selection bias in prior research on IB (i.e., student demographics and test scores). Instead, our analyses show that the strongest predictors of IB participation were indicators of academic challenge and success in prior grades; specifically, enrolling in advanced courses during 8th, 9th and 10th grades. This conclusion suggests that future research on IB and other credit-based transition programs should dig deeper into administrative data and include indicators derived from middle school and high school transcripts.

Although propensity score models are often seen as a viable option to support causal inference in observational studies, methodologists too often fail to connect theory to analysis. Propensity score models are estimated using whatever data are available and the degree of overlap in propensity scores is not examined. Without a strong and comprehensive theory of the selection mechanism in an observational study, we run the risk of drawing unjustified inferences. Worse yet, our results in this study of IB suggest that once the propensity score model includes a substantial number of predictors from the theoretical model of selection, the propensity score results serve only to confirm that we are comparing apples and oranges and no statistical adjustment will yield decent causal inference (Rubin, 2004, p. 354).

Appendices

Not included in page count.

Appendix A. References

References are to be in APA version 6 format.

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Appendix B. Tables and Figures

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Figure 1. Conceptual Model of the Inputs/Predictors of Students' Participation in IB

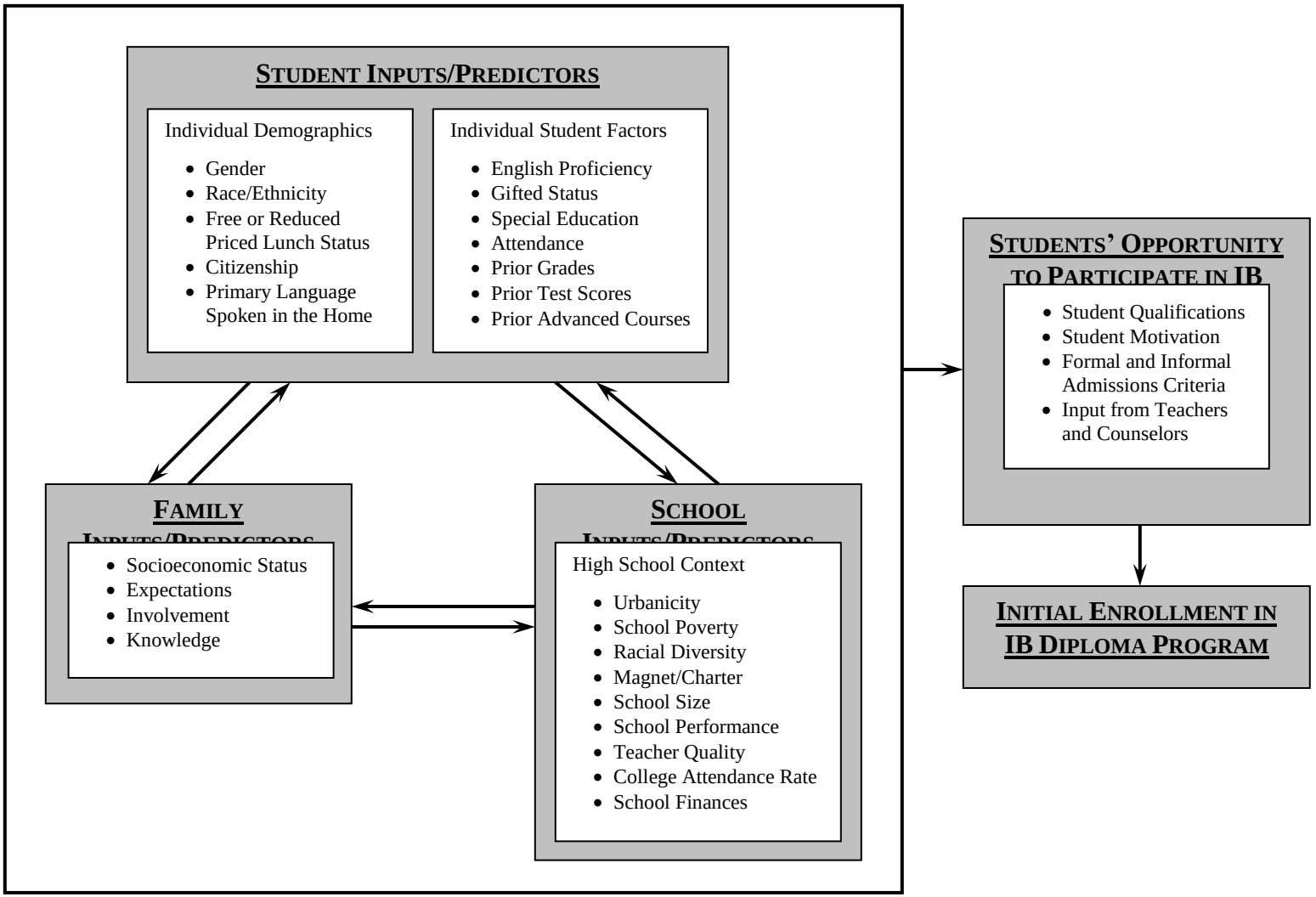

Figure 2. Density Plots of Estimated Propensity Scores for Six Cohorts of IB and Non-IB Students

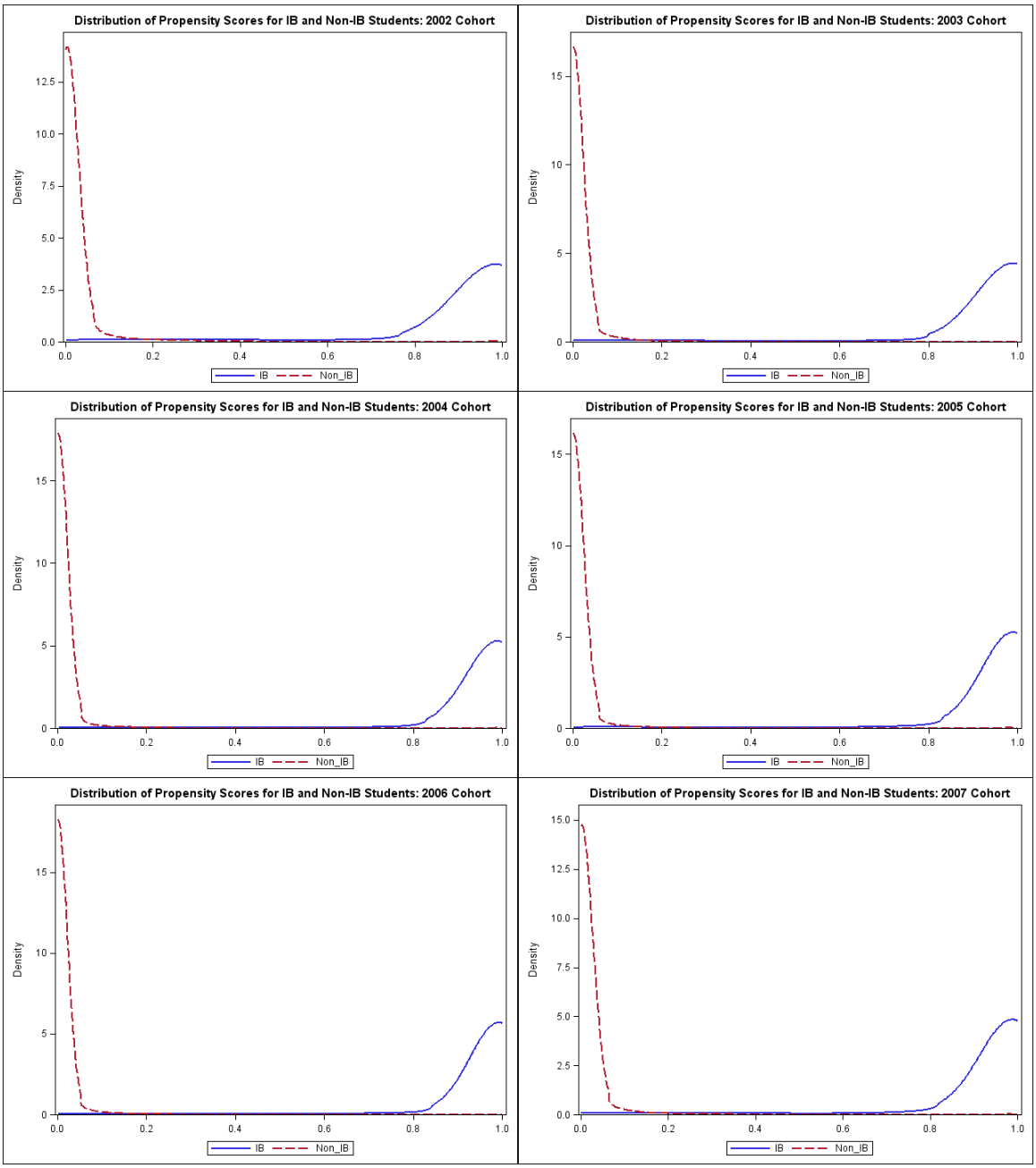

Table 1. Bivariate Odds Ratios for Student Demographic Predictors of Participation in the International Baccalaureate (IB) Diploma Programme

	Year of High School Graduation						
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2002-07**
Number of IB Students	2,927	3,000	3,223	3,507	3,754	3,962	20,373
Number of Non-IB Students	13,108	13,937	14,215	14,247	14,888	15,613	86,008
Predictor Variable							
Male	0.81**	0.81**	0.85*	0.77***	0.77***	0.82**	0.81***
Race/Ethnicity (Caucasian reference)							
Asian	2.95***	3.06***	2.96***	3.02***	2.88***	3.63***	3.09***
African American	0.28***	0.26***	0.26***	0.27***	0.28***	0.24***	0.27***
Hispanic/Latino/Latina	0.62***	0.51***	0.57***	0.66***	0.62***	0.56***	0.59***
Native American	0.61	1.02	0.62	0.73	0.96	0.39*	0.68~
Multiracial	0.24~	0.17*	0.11**	1.41	1.21	0.46	0.51**
US Residency Status							
Nonresident Alien	1.20	1.13	7.81**	1.34	1.63	3.13	2.13**
US Citizen	1.16	1.58***	1.31*	1.47***	1.37**	1.59***	1.41***
Born outside the US	0.95	0.85~	1.09	1.01	1.07	1.04	1.00
Family Language							
English	1.33**	1.50***	1.30**	1.13	1.26**	1.10	1.25***
Parent speaks English	1.32**	1.43***	1.23*	1.05	1.15	1.10	1.19***
School Program Participation							
Limited English Proficiency	0.16***	0.18***	0.13***	0.14***	0.11***	0.11***	0.14***
Special Education Student	0.53***	0.38***	0.37***	0.40***	0.43***	0.47***	0.42***
Free/Reduced Lunch Eligible	0.31***	0.30***	0.28***	0.35***	0.30***	0.29***	0.30***
Gifted Student	7.35***	7.30***	9.05***	6.06***	5.95***	6.80***	6.97***

Note. ~p<.10, *p<.05, **p<.01, ***p<.001
Odds ratios in this table are based on bivariate multilevel models (students within schools) with no control variables.

Table 2. Bivariate Odds Ratios for Student Performance Indicators as Predictors of Participation in the International Baccalaureate (IB) Diploma Programme

	Year of High School Graduation						
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2002-07**
Number of IB Students	2,927	3,000	3,223	3,507	3,754	3,962	20,373
Number of Non-IB Students	13,108	13,937	14,215	14,247	14,888	15,613	86,008
Predictor Variable							
Average Attendance Rate[a]	1.80***	2.00***	1.88***	1.97***	1.90***	2.12***	1.95***
Retained in Grade at Least Once	0.14***	0.34***	0.10***	0.09***	0.07***	0.07***	0.13***
Prior Grade Point Average[a]							
Unweighted 9th Grade GPA	3.26***	3.30***	3.41***	3.69***	3.55***	3.88***	3.52***
Unweighted 10th Grade GPA	2.68***	3.03***	2.66***	2.99***	2.70***	3.03***	2.85***
Weighted 9th Grade GPA	4.60***	4.86***	5.21***	5.53***	5.31***	5.62***	5.18***
Weighted 10th Grade GPA	3.70***	4.36***	3.97***	4.36***	3.92***	4.26***	4.09***
Prior FCAT State Test Scores[a]							
Mean FCAT Math Score in Grades 3-8				6.34***	7.98***	8.14***	7.42***
Mean FCAT Reading Score in Grades 3-8				4.24***	5.92***	6.20***	5.37***
Mean FCAT Math Score in Grades 9-10		6.99***	8.08***	7.59***	7.07***	7.84***	7.49***
Mean FCAT Reading Score in Grades 9-10		5.28***	7.07***	6.62***	6.11***	6.02***	6.17***

Note. ~p<.10, *p<.05, **p<.01, ***p<.001

Odds ratios in this table are based on bivariate multilevel models (students within schools) with no control variables.

[a] Odds ratios for continuous variables represent difference in odds associated with a one standard deviation increase in the predictor.

Table 3. Bivariate Odds Ratios for Early High School Course-Taking Indicators as Predictors of Participation in the International Baccalaureate (IB) Diploma Programme

	Year of High School Graduation						
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2002-07**
Number of IB Students	2,927	3,000	3,223	3,507	3,754	3,962	20,373
Number of Non-IB Students	13,108	13,937	14,215	14,247	14,888	15,613	86,008
Predictor Variable							
Highest Math Through 10th Grd. (reference: Algebra II)							
Basic Math	0.07***	0.02***	0.02***	0.02***	0.01***	0.04***	0.03***
Algebra I	0.02***	0.01***	0.01***	0.01***	0.01***	0.01***	0.01***
Geometry	0.07***	0.04***	0.02***	0.02***	0.02***	0.03***	0.03***
Trigonometry/Pre-calculus	11.27***	8.56***	8.12***	7.53***	8.17***	6.92***	8.20***
Calculus or Above	1.97~	1.76	1.44	6.84**	3.13*	2.41*	2.34***
Late Algebra I (after 9th Grade)	0.06***	0.04***	0.04***	0.05***	0.04***	0.04***	0.04***
Early Algebra I (before 9th Grade)	17.58***	25.07***	25.97***	21.20***	26.53***	23.73***	23.15***
Advanced Credits in 9th Grade[a]	15.19***	13.12***	14.95***	24.51***	26.42***	16.89***	17.78***
Advanced Credits in 10th Grade	26.63***	31.13***	39.37***	88.66***	121.7***	35.99***	43.29***

Note. ~p<.10, *p<.05, **p<.01, ***p<.001
Odds ratios in this table are based on bivariate multilevel models (students within schools) with no control variables.
[a] Odds ratios for continuous variables represent difference in odds associated with a one standard deviation increase in the predictor.

Table 4. Bivariate Odds Ratios for School-Level Predictors of Participation in the International Baccalaureate (IB) Diploma Programme

	Year of High School Graduation						
	2002	**2003**	**2004**	**2005**	**2006**	**2007**	**2002-07**
Number of IB Students	2,927	3,000	3,223	3,507	3,754	3,962	20,373
Number of Non-IB Students	13,108	13,937	14,215	14,247	14,888	15,613	86,008
Predictor Variable							
Regular School (vs. Alternative or Special Ed)	0.50	0.58	0.81	0.32	0.36	2.14	0.58~
Magnet School					3.60***	5.98***	4.67***
Charter School	3.17	0.01	0.00	0.24	0.75	0.36	0.48
New School	1.29	0.01	1.59	0.01	6.21	2.09	1.32
Urban	1.05	0.87	1.02	1.07	1.05	1.00	1.01
Rural	0.53	0.28*	0.28*	0.39~	0.31*	0.45~	0.37***
Title I School	0.74	1.01	0.56	0.64	0.34	0.82	0.73
School-Wide Title I	0.69	1.11	0.52	0.74	0.39	0.71	0.70
Pupil/Teacher Ratio[a]	0.93	0.76	0.76~	0.79	0.84	0.82	0.81**
Percent Free/Reduced Lunch[a]	0.86	0.75	0.70*	0.76	0.77	0.73~	0.76***
Percent Asian[a]	3.90***	4.24***	4.97***	4.71***	4.06***	4.10***	4.30***
Percent Hispanic/Latino/Latina[a]	0.66~	0.74	0.65*	0.66~	0.74	0.83	0.72***
Percent African American[a]	1.18	1.13	1.14	1.08	1.22	1.02	1.13~
Percent White[a]	0.98	0.98	1.02	1.07	0.93	1.01	1.00
School Size[a]	0.93	1.03	0.99	1.05	1.03	1.24	1.05
School Mean FCAT Math Scores in Grades 9-10		9.47***	8.41***	10.02**	7.77***	10.59**	11.54**
School Mean FCAT Reading Scores in Grades 9-10		8.75***	6.01***	9.81***	7.35***	11.36**	8.41***

Note. ~p<.10, *p<.05, **p<.01, ***p<.001
Odds ratios in this table are based on bivariate multilevel models (students within schools) with no control variables.
[a] Odds ratios for continuous variables represent difference in odds associated with a one standard deviation increase in the predictor.

Table 5. Parameter Estimates from a Multiple Logistic Regression Predicting Participation in the International Baccalaureate (IB) Diploma Programme

	Year of High School Graduation					
	2002	**2003**	**2004**	**2005**	**2006**	**2007**
Number of IB Students	2,927	3,000	3,223	3,507	3,754	3,962
Number of Non-IB Students	13,108	13,937	14,215	14,247	14,888	15,613
Predictor Variable						
Intercept	-1.84$^{\sim}$	-6.06**	-5.73**	-3.04*	-2.53*	-7.27***
	(0.98)	(1.85)	(1.80)	(1.43)	(1.24)	(2.08)
Male	-0.08	0.05	0.25	-0.11	0.09	0.12
	(0.14)	(0.17)	(0.18)	(0.17)	(0.17)	(0.14)
Asian	-0.06	0.67$^{\sim}$	0.58	0.92**	0.59$^{\sim}$	0.35
	(0.30)	(0.37)	(0.36)	(0.33)	(0.33)	(0.29)
African American	-0.13	0.10	0.08	-0.15	0.12	-0.10
	(0.22)	(0.27)	(0.29)	(0.31)	(0.31)	(0.25)
Hispanic	0.31	0.28	0.38	0.25	0.10	0.18
	(0.28)	(0.29)	(0.31)	(0.29)	(0.27)	(0.24)
Native American	-0.58	0.27	-2.43	-1.34	0.09	-0.09
	(1.06)	(1.01)	(2.07)	(1.07)	(1.48)	(1.20)
Multiracial	0.02	-1.03	-1.10	3.10***	0.45	0.24
	(1.34)	(1.89)	(3.01)	(0.90)	(1.33)	(1.60)
Non-Resident Alien	-1.84	-0.15	0.01	-0.45	-1.46	1.49
	(2.56)	(1.42)	(1.61)	(1.34)	(1.45)	(1.15)
US Citizen	-1.01*	0.48	-0.35	-0.04	0.09	-0.28
	(0.49)	(0.47)	(0.49)	(0.43)	(0.42)	(0.38)
Born outside of the US	-0.64	0.63	-0.01	0.37	0.35	0.27
	(0.48)	(0.44)	(0.42)	(0.39)	(0.38)	(0.34)
English is home language	-0.35	-0.45	-0.10	0.22	0.07	-0.05
	(0.39)	(0.42)	(0.49)	(0.42)	(0.41)	(0.33)
Parents speak English	0.17	0.57	-0.42	-0.35	-0.55	-0.12
	(0.40)	(0.42)	(0.49)	(0.39)	(0.39)	(0.31)
Limited English Proficiency	-0.28	-0.41	-0.26	-0.29	0.15	-0.40
	(0.32)	(0.38)	(0.40)	(0.42)	(0.39)	(0.34)
Special Education Student	0.92***	0.17	0.14	-0.02	-0.27	-0.25
	(0.23)	(0.30)	(0.32)	(0.29)	(0.29)	(0.23)
Gifted Student	0.13	0.21	0.24	-0.01	-0.14	0.19
	(0.17)	(0.20)	(0.22)	(0.21)	(0.21)	(0.18)
Free/Reduced Lunch Eligible	0.11	-0.16	-0.04	-0.04	-0.21	-0.07
	(0.17)	(0.19)	(0.21)	(0.20)	(0.20)	(0.16)

$^{\sim}$p<.10, *p<.05, **p<.01, ***p<.001

Table 5 (continued). Parameter Estimates from a Multiple Logistic Regression Predicting Participation in the International Baccalaureate (IB) Diploma Programme

	Year of High School Graduation					
Predictor Variable	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Average Attendance Rate	-0.09	-0.09	-0.24*	0.09	0.07	0.18~
	(0.08)	(0.08)	(0.10)	(0.10)	(0.11)	(0.09)
Retained in Grade at Least Once	0.17	0.52~	0.21	0.07	-0.62	0.11
	(0.28)	(0.30)	(0.36)	(0.37)	(0.45)	(0.30)
Unweighted GPA in 9th Grade	-0.75	0.39	-1.25	-0.27	-1.73~	-0.84
	(0.67)	(0.94)	(0.95)	(0.93)	(0.95)	(0.67)
Weighted GPA in 9th Grade	0.98	-0.17	1.62	0.51	2.24~	1.11
	(0.74)	(1.08)	(1.06)	(1.02)	(1.09)	(0.76)
Unweighted GPA in 10th Grade	-1.19~	-1.18	-1.18	-2.27**	-1.45~	-0.74
	(0.64)	(0.78)	(0.92)	(0.81)	(0.84)	(0.69)
Weighted GPA in 10th Grade	1.78*	1.75*	1.77~	2.82**	1.76~	1.23
	(0.72)	(0.85)	(1.04)	(0.89)	(0.94)	(0.77)
Mean FCAT Math Score Gd 3-8				0.02	0.11	-0.38*
				(0.17)	(0.23)	(0.19)
Mean FCAT Reading Scr Gd 3-8				0.10	-0.03	0.54**
				(0.13)	(0.17)	(0.17)
Mean FCAT Math Scr Gd 9-10		0.14	0.03	0.04	-0.19	0.08
		(0.12)	(0.15)	(0.17)	(0.19)	(0.15)
Mean FCAT Read Scr Gd 9-10		0.22~	0.36**	0.25~	0.36**	-0.03
		(0.12)	(0.12)	(0.14)	(0.14)	(0.13)
Basic Math	0.88~	-1.56	1.12	-0.80	-1.02	0.90
	(0.48)	(1.18)	(0.84)	(1.27)	(1.75)	(0.90)
Algebra I	0.10	0.07	0.62	-0.17	0.41	-0.49
	(0.33)	(0.38)	(0.51)	(0.44)	(0.47)	(0.41)
Geometry	0.31	-0.04	0.13	-0.71*	-0.49	-0.16
	(0.27)	(0.28)	(0.32)	(0.31)	(0.33)	(0.25)
Trigonometry/Pre-calculus	0.43	0.27	-0.27	0.05	0.21	0.67**
	(0.28)	(0.30)	(0.30)	(0.30)	(0.31)	(0.25)
Calculus or Above	-1.61~	-1.42	-1.72~	0.15	-1.35	-1.15
	(0.85)	(1.14)	(1.01)	(0.98)	(0.89)	(0.79)
Early Algebra I	0.59*	0.73**	0.76**	0.14	0.19	0.26
	(0.25)	(0.26)	(0.27)	(0.26)	(0.30)	(0.23)
Advanced Credits in 9th Grade	1.12***	0.75***	0.95***	1.23***	1.21***	1.04***
	(0.12)	(0.12)	(0.15)	(0.16)	(0.14)	(0.12)
Advanced Credits in 10th Grade	1.91***	2.42***	2.65***	2.86***	2.83***	2.24***
	(0.13)	(0.17)	(0.18)	(0.20)	(0.17)	(0.14)

~p<.10, *p<.05, **p<.01, ***p<.001

Table 5 (continued). Parameter Estimates from a Multiple Logistic Regression Predicting Participation in the International Baccalaureate (IB) Diploma Programme

	Year of High School Graduation					
Predictor Variable	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Regular School	-1.85*	-1.35	-0.27	-3.07*	-2.92**	1.16
	(0.77)	(1.70)	(1.52)	(1.31)	(1.07)	(1.99)
Magnet School					-0.06	0.41
					(0.56)	(0.53)
Charter School	2.30	-20.03	-7.93	1.92	3.09*	1.63
	(1.88)	(66.46)	(12.38)	(2.35)	(1.22)	(1.28)
New School	1.85	-3.85	-1.92	-0.23	5.24**	6.06*
	(1.55)	(786.73)	(2.86)	(6.33)	(1.89)	(2.62)
Urban	-0.11	-1.01	-0.29	-0.17	0.21	0.15
	(0.39)	(0.64)	(0.56)	(0.60)	(0.50)	(0.52)
Rural	-0.03	-0.88	-0.69	-0.29	-0.48	0.12
	(0.44)	(0.84)	(0.73)	(0.70)	(0.61)	(0.57)
Title1 Eligible	1.47	-16.91	1.82	-2.71	-9.81	1.53*
	(1.59)	(110.26)	(1.82)	(6.61)	(427.90)	(0.73)
School-wide Title1	-2.08	16.85	-3.34	1.68	8.17	-0.85
	(1.88)	(110.25)	(2.04)	(6.73)	(427.90)	(0.76)
Pupil/Teacher Ratio	-0.15	-0.48	-0.18	-0.48	-0.56*	-0.22
	(0.23)	(0.43)	(0.33)	(0.35)	(0.23)	(0.20)
Percent Free/Reduced Lunch	0.48*	0.91*	0.65~	1.22**	1.19***	0.50
	(0.22)	(0.38)	(0.37)	(0.38)	(0.35)	(0.47)
Percent Asian	1.78	-0.69	0.97	1.72	0.01	1.48
	(1.36)	(2.36)	(1.66)	(2.25)	(2.16)	(2.41)
Percent Hispanic/Latino/Latina	8.40	-10.73	-0.62	9.12	-1.49	11.22
	(12.73)	(21.78)	(14.83)	(20.01)	(18.51)	(20.48)
Percent African American	8.42	-9.66	0.31	9.14	-1.36	10.42
	(12.11)	(20.60)	(14.03)	(18.39)	(17.05)	(18.48)
Percent White	10.97	-13.23	-0.01	12.31	-1.72	14.00
	(15.91)	(27.37)	(18.41)	(24.53)	(22.69)	(24.82)
School Size	-0.02	0.09	-0.00	0.44	0.41	0.66*
	(0.24)	(0.41)	(0.38)	(0.34)	(0.27)	(0.29)
School Mean FCAT Math Scores in Grades 9-10		1.20	2.69**	-0.54	1.12~	0.16
		(0.79)	(0.81)	(0.77)	(0.61)	(0.73)
School Mean FCAT Reading Scores in Grades 9-10		0.75	-1.40~	2.34**	0.79	1.87*
		(0.81)	(0.70)	(0.82)	(0.62)	(0.75)
Model Concordance Index	99.5	99.3	99.5	99.4	99.4	99.2

~p<.10, *p<.05, **p<.01, ***p<.001

Table 6. Counts of IB and Non-IB students in Five Propensity Score Strata

	Propensity Score Strata (Predicted Probability of IB Participation)				
Graduation Year	0.00 – 0.20	0.20 – 0.40	0.40 – 0.60	0.60 – 0.80	0.80 – 1.00
2002					
Non-IB Students	12,839	170	42	12	45
	97.9%	1.3%	0.3%	0.1%	0.3%
IB Students	89	72	53	69	2,644
	3.0%	2.5%	1.8%	2.4%	90.3%
2003					
Non-IB Students	13,775	70	34	21	37
	98.8%	0.5%	0.2%	0.2%	0.3%
IB Students	75	44	39	47	2,795
	2.5%	1.5%	1.3%	1.6%	93.2%
2004					
Non-IB Students	14,066	74	24	12	39
	99.0%	0.5%	0.2%	0.1%	0.3%
IB Students	59	29	29	48	3,058
	1.8%	0.9%	0.9%	1.5%	94.9%
2005					
Non-IB Students	14,068	80	30	20	49
	98.7%	0.6%	0.2%	0.1%	0.3%
IB Students	70	28	28	67	3,314
	2.0%	0.8%	0.8%	1.9%	94.5%
2006					
Non-IB Students	14,725	82	32	10	39
	98.9%	0.6%	0.2%	0.1%	0.3%
IB Students	60	37	27	65	3,565
	1.6%	1.0%	0.7%	1.7%	95.0%
2007					
Non-IB Students	15,376	106	43	23	65
	98.5%	0.7%	0.3%	0.1%	0.4%
IB Students	78	58	55	85	3,686
	2.0%	1.5%	1.4%	2.1%	93.0%
Total					
Non-IB Students	84,849	582	205	98	274
	98.7%	0.7%	0.2%	0.1%	0.3%
IB Students	431	268	231	381	19,062
	2.1%	1.3%	1.1%	1.9%	93.6%

Table 7. Bivariate Odds Ratios for Student Demographic Predictors of Participation in the International Baccalaureate (IB) Diploma Programme

	Odds Ratios for IB vs. Non-IB Students			
	Unadjusted	**Propensity Stratification Adjusted**	**Propensity Matching Adjusted**	**Percent Reduction in Selection Bias**
Predictor Variable				
Male	0.81***	0.99	0.98	94% , 89%
Race/Ethnicity (Caucasian reference)				
Asian	3.09***	1.17	1.13	86% , 89%
African American	0.27***	0.99	1.00	99% , 100%
Hispanic/Latino/Latina	0.59***	1.05	1.05	108% , 110%
Native American	0.68~	0.97	1.15	n/s , n/s
Multiracial	0.51**	1.16	1.53	121% , 162%
US Residency Status				
Nonresident Alien	2.13**	0.92	1.23	111% , n/s
US Citizen	1.41***	0.88	0.89	138% , 134%
Born outside the US	1.00	1.12	1.12	n/s , n/s
Family Language				
English	1.25***	0.87	0.90	163% , 150%
Parent speaks English	1.19***	0.92	0.91	146% , 155%
School Program Participation				
Limited English Proficiency	0.14***	0.91	0.97	95% , 98%
Special Education Student	0.42***	0.99	0.96	98% , 95%
Free/Reduced Lunch Eligible	0.30***	0.98	0.99	98% , 99%
Gifted Student	6.97***	1.05	1.06	98% , 97%

Note. ~p<.10, *p<.05, **p<.01, ***p<.001; n/s denotes non-significant change in odds ratios (i.e., p >.10)
Odds ratios in this table are based on bivariate multilevel models (students within schools).

Table 8. Bivariate Odds Ratios for Student Performance Indicators as Predictors of Participation in the International Baccalaureate (IB) Diploma Programme

	Odds Ratios for IB vs. Non-IB Students			
	Unadjusted	**Propensity Stratification Adjusted**	**Propensity Matching Adjusted**	**Percent Reduction in Selection Bias**
Predictor Variable				
Average Attendance Rate[a]	1.95***	1.01	1.02	98% , 97%
Retained in Grade at Least Once	0.13***	0.87	0.94	93% , 97%
Prior Grade Point Average[a]				
Unweighted 9th Grade GPA	3.52***	1.17***	1.11**	88% , 92%
Unweighted 10th Grade GPA	2.85***	1.21***	1.15***	82% , 87%
Weighted 9th Grade GPA	5.18***	1.18***	1.11**	90% , 93%
Weighted 10th Grade GPA	4.09***	1.22***	1.16***	86% , 90%
Prior FCAT State Test Scores[a]				
Mean FCAT Math Score in Grades 3-8	7.42***	1.15*	1.06	93% , 97%
Mean FCAT Reading Score in Grades 3-8	5.37***	1.17**	1.07	91% , 96%
Mean FCAT Math Score in Grades 9-10	7.49***	1.18***	1.10*	92% , 95%
Mean FCAT Reading Score in Grades 9-10	6.17***	1.18***	1.10*	91% , 95%

Note. ~p<.10, *p<.05, **p<.01, ***p<.001; n/s denotes non-significant change in odds ratios (i.e., p >.10)
Odds ratios in this table are based on bivariate multilevel models (students within schools).

[a] Odds ratios for continuous variables represent difference in odds associated with a one standard deviation increase in the predictor.

Table 9. Bivariate Odds Ratios for Early High School Course-Taking Indicators as Predictors of Participation in the International Baccalaureate (IB) Diploma Programme

	Odds Ratios for IB vs. Non-IB Students			
	Unadjusted	**Propensity Stratification Adjusted**	**Propensity Matching Adjusted**	**Percent Reduction in Selection Bias**
Predictor Variable				
Highest Math Through 10th Grd. (reference: Algebra II)				
Basic Math	0.03***	0.88	0.91	96% , 97%
Algebra I	0.01***	1.05	1.07	101% , 101%
Geometry	0.03***	1.04	1.09	101% , 102%
Trigonometry/Pre-calculus	8.20***	1.25~	1.38**	89% , 85%
Calculus or Above	2.34***	1.53	1.40	n/s , 61%
Late Algebra I (after 9th Grade)	0.04***	0.91	0.92	97% , 97%
Early Algebra I (before 9th Grade)	23.15***	1.10	1.08	97% , 97%
Advanced Credits in 9th Grade[a]	17.78***	0.89*	1.05	104% , 98%
Advanced Credits in 10th Grade[a]	43.29***	0.91~	1.16**	102% , 96%

Note. ~p<.10, *p<.05, **p<.01, ***p<.001; n/s denotes non-significant change in odds ratios (i.e., p >.10)
Odds ratios in this table are based on bivariate multilevel models (students within schools).
[a] Odds ratios for continuous variables represent difference in odds associated with a one standard deviation increase in the predictor.

Table 10. Bivariate Odds Ratios for School-Level Predictors of Participation in the International Baccalaureate (IB) Diploma Programme

	Odds Ratios for IB vs. Non-IB Students			
	Unadjusted	**Propensity Stratification Adjusted**	**Propensity Matching Adjusted**	**Percent Reduction in Selection Bias**
Predictor Variable				
Regular School (vs. Alternative or Special Ed)	0.58~	0.62~	0.95	n/s , 90%
Magnet School	4.67***	1.29*	1.04	83% , 97%
Charter School	0.48	0.87	0.99	n/s , 99%
New School	1.32	1.81	1.14	n/s , n/s
Urban	1.01	0.90	0.93	n/s , n/s
Rural	0.37***	0.85	0.88	83% , 87%
Title I School	0.73	1.02	1.09	107% , 128%
School-Wide Title I	0.70	0.99	1.07	98% , 118%
Pupil/Teacher Ratio[a]	0.81**	0.96	0.98	80% , 89%
Percent Free/Reduced Lunch[a]	0.76***	1.04	1.07*	115% , 126%
Percent Asian[a]	4.30***	1.03	0.99	98% , 101%
Percent Hispanic/Latino/Latina[a]	0.72***	0.98	1.02	94% , 107%
Percent African American[a]	1.13~	1.06~	1.06~	n/s , n/s
Percent White[a]	1.00	0.96	0.94~	n/s , n/s
School Size[a]	1.05	1.01	0.98	n/s , n/s
School Mean FCAT Math Scores in Grades 9-10	13.88***	1.27***	1.02	91% , 99%
School Mean FCAT Reading Scores in Grades 9-10	8.41***	1.23***	1.01	90% , 100%

Note. ~p<.10, *p<.05, **p<.01, ***p<.001; n/s denotes non-significant change in odds ratios (i.e., p >.10)
Odds ratios in this table are based on bivariate multilevel models (students within schools).

[a] Odds ratios for continuous variables represent difference in odds associated with a one standard deviation increase in the predictor.

Table 11. Student Demographics for Matched and Unmatched Students from the International Baccalaureate (IB) Diploma Programme

	IB Students		Matched Non-IB Students (C)	Odds Ratios	
	Unmatched (A)	Matched (B)		A vs. B	B vs. C
Predictor Variable					
Male	42.3%	43.5%	44.2%	1.08	0.97
Race/Ethnicity (Caucasian reference)					
Asian	13.8%	6.6%	6.3%	0.55***	1.06
African American	9.9%	16.0%	16.3%	1.91***	1.00
Hispanic/Latino/Latina	13.3%	18.6%	17.0%	1.46***	1.12
Native American	0.4%	0.4%	0.5%	1.49	0.87
Multiracial	0.2%	0.1%	0.4%	0.44	0.41
US Residency Status					
Nonresident Alien	0.3%	0.3%	0.0%	n/a	n/a
US Citizen	91.5%	88.2%	89.3%	0.79*	0.89
Born outside the US	13.5%	15.4%	14.9%	1.06	1.04
Family Language					
English	85.6%	83.0%	83.7%	0.85~	0.95
Parent speaks English	83.3%	81.3%	82.0%	0.89	0.95
School Program Participation					
Limited English Proficiency	1.3%	4.2%	4.2%	2.54***	0.98
Special Education Student	5.5%	8.7%	9.3%	1.39**	0.93
Free/Reduced Lunch Eligible	22.1%	34.2%	34.2%	1.75***	1.00
Gifted Student	47.8%	26.7%	25.7%	0.45***	1.06

Note. ~p<.10, *p<.05, **p<.01, ***p<.001
Odds ratios in this table are based on bivariate multilevel models (students within schools).

Table 12. Student Performance Indicators for Matched and Unmatched Students from the International Baccalaureate (IB) Diploma Programme

	IB Students		Matched Non-IB Students (C)	Odds Ratios	
	Unmatched (A)	Matched (B)		A vs. B	B vs. C
Predictor Variable					
Average Attendance Rate[a]	97%	96%	96%	0.73***	1.00
Retained in Grade at Least Once	2.2%	6.5%	7.1%	3.61***	0.91
Prior Grade Point Average[a]					
Unweighted 9th Grade GPA	3.46	3.24	3.13	0.58***	1.22***
Unweighted 10th Grade GPA	3.38	3.18	3.15	0.66***	1.06
Weighted 9th Grade GPA	3.74	3.41	3.32	0.45***	1.20***
Weighted 10th Grade GPA	3.66	3.37	3.34	0.53***	1.06
Prior FCAT State Test Scores[a]					
Mean FCAT Math Score in Grades 3-8	379	351	350	0.33***	1.04
Mean FCAT Reading Score in Grades 3-8	373	345	343	0.42***	1.05
Mean FCAT Math Score in Grades 9-10	376	355	354	0.35***	1.05
Mean FCAT Reading Score in Grades 9-10	373	348	348	0.41***	1.01

Note. ~p<.10, *p<.05, **p<.01, ***p<.001
Odds ratios in this table are based on bivariate multilevel models (students within schools).
[a] Odds ratios for continuous variables represent difference in odds associated with a one standard deviation increase in the predictor.

Table 13. Early High School Course-Taking Indicators for Matched and Unmatched Students from the International Baccalaureate (IB) Diploma Programme

	IB Students		Matched Non-IB Students (C)	Odds Ratios	
	Unmatched (A)	Matched (B)		A vs. B	B vs. C
Predictor Variable					
Highest Math Through 10th Grd. (reference: Algebra II)					
Basic Math	0.1%	1.2%	1.0%	7.83***	1.34
Algebra I	0.1%	9.0%	8.2%	67.56***	1.19
Geometry	2.7%	26.3%	25.0%	15.79***	1.14
Trigonometry/Pre-calculus	36.0%	12.1%	10.8%	0.34***	1.22
Calculus or Above	2.2%	1.1%	0.7%	0.54*	1.63
Late Algebra I (after 9th Grade)	13.7%	42.6%	41.9%	4.84***	1.03
Early Algebra I (before 9th Grade)	86.3%	57.4%	58.0%	0.21***	0.97
Advanced Credits in 9th Grade[a]	5.0	1.0	1.5	0.12***	0.80***
Advanced Credits in 10th Grade[a]	4.6	1.4	1.1	0.06***	1.19***

Note. ~p<.10, *p<.05, **p<.01, ***p<.001
Odds ratios in this table are based on bivariate multilevel models (students within schools).
[a] Odds ratios for continuous variables represent difference in odds associated with a one standard deviation increase in the predictor.

Table 14. School-Level Predictors for Matched and Unmatched Students from the International Baccalaureate (IB) Diploma Programme

	IB Students		Matched Non-IB Students (C)	Odds Ratios	
	Unmatched (A)	Matched (B)		A vs. B	B vs. C
Predictor Variable					
Regular School (vs. Alternative or Special Ed)	99.9%	98.4%	98.9%	0.17**	0.68
Magnet School	60.4%	46.2%	47.7%	0.19***	0.94
Charter School	0.0%	0.7%	0.6%	11.86**	1.13
New School	0.0%	0.3%	0.2%	5.58	1.34
Urban	34.3%	30.0%	32.2%	1.44	0.89
Rural	5.4%	11.7%	11.8%	4.00***	0.95
Title I School	12.7%	13.3%	13.6%	0.74	0.97
School-Wide Title I	10.4%	9.3%	9.2%	0.47*	1.02
Pupil/Teacher Ratio[a]	19.4	19.6	19.6	1.11	1.02
Percent Free/Reduced Lunch[a]	26.9%	26.1%	25.5%	1.21	1.04
Percent Asian[a]	5.1%	4.3%	4.6%	0.50***	0.93*
Percent Hispanic/Latino/Latina[a]	15.7%	17.1%	16.6%	1.04	1.03
Percent African American[a]	27.1%	22.9%	23.2%	0.71***	0.99
Percent White[a]	51.8%	55.4%	55.4%	1.47***	1.00
School Size[a]	2247	2259	2254	0.74**	1.01
School Mean FCAT Math Scores in Grades 9-10	362	353	355	0.24***	0.88*
School Mean FCAT Reading Scores in Grades 9-10	358	347	349	0.28***	0.88**

Note. ~p<.10, *p<.05, **p<.01, ***p<.001
Odds ratios in this table are based on bivariate multilevel models (students within schools).
[a] Odds ratios for continuous variables represent difference in odds associated with a one standard deviation increase in the predictor.

Table 15. SAT and ACT Test Score Averages and Missing Data Rates for International Baccalaureate (IB) Diploma Programme Participants and Non-Participants

	Non-IB Students		IB Students	
Postsecondary Indicator	**Unmatched**	**Matched**	**Matched**	**Unmatched**
SAT Math Score	505.8 (49%)	561.9 (22%)	575.3 (19%)	628.5 (4%)
SAT Verbal Score	504.1 (49%)	557.7 (22%)	579.9 (19%)	626.5 (4%)
SAT Writing Score	480.0 (90%)	524.3 (85%)	545.3 (83%)	608.6 (81%)
ACT Math Score	21.2 (68%)	23.5 (50%)	23.9 (50%)	26.4 (46%)
ACT Reading Score	22.1 (68%)	24.2 (50%)	25.3 (50%)	27.6 (46%)
ACT English Score	20.7 (68%)	23.1 (50%)	24.0 (50%)	26.4 (46%)

Table 16. College Enrollment Rates for International Baccalaureate (IB) Diploma Programme Participants and Non-Participants

	Non-IB Students		IB Students	
Postsecondary Indicator	**Unmatched**	**Matched**	**Matched**	**Unmatched**
Immediate College Enrollment	75.7%	83.4%	84.1%	86.0%
Enrollment in a 4-Year Institution	55.0%	72.6%	69.5%	78.0%
Enrollment in a Selective Institution	18.8%	36.4%	33.9%	34.0%

Note. Missing data rates for enrollment indicators are unknown given that non-enrollment is observed as missing data.

Table 17. Differences in Postsecondary Indicators for International Baccalaureate (IB) Diploma Programme Participants and Non-Participants with and without Propensity Score Adjustments

Postsecondary Indicator	Unadjusted	Propensity Stratification	Propensity Full-Matching	Propensity Pair-Matching
Continuous Outcomes (Mean Differences)				
SAT Math Score	120.90***	14.03***	29.00***	15.22***
SAT Verbal Score	119.10***	21.39***	35.30***	25.12***
SAT Writing Score	126.30***	20.06**	30.25***	28.68**
ACT Math Score	5.28***	0.35~	1.00***	0.38
ACT Reading Score	5.41***	0.87***	1.52***	1.15***
ACT English Score	5.62***	0.71***	1.36***	1.02***
Categorical Outcomes (Odds Ratios)				
Immediate College Enrollment	1.94***	1.02	1.04	1.09***
Enrollment in a 4-Year Institution	2.57***	0.95	1.06	0.83***
Enrollment in a Selective Institution	2.15***	0.95	1.00	0.89

Note. ~p<.10, *p<.05, **p<.01, ***p<.001
Adjusted mean differences and odds ratios in this table are based on bivariate multilevel models (students within schools).