The Role of Demographic Factors
in Predicting Student Performance on a State Reading Test

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Paper Presented at the Annual Meeting
of the American Educational Research Association
San Francisco, April 2006

I. Introduction

The overall goal of the No Child Left Behind Act (NCLB) of 2001 is to close, by the end of the 2013-2014 academic year, "the achievement gap between high- and low-performing children, especially the achievement gap between minority and non-minority students, and between disadvantaged children and their more advantaged peers" (NCLB, 2001, Sec. 1001[3]). Under the federal NCLB mandates, adequate yearly progress (AYP) targets must be set for the entire period from 2002 to 2014 in order to ensure that all students and all schools eventually meet the content and performance standards adopted in their respective states. It was within this context that the Hawaii Department of Education (HDOE) launched its Hawaii State Assessment (HSA) in spring, 2002.

The accountability provisions in NCLB clearly refer to two demographic variables underlying the current inequity in public education: economic disadvantage and race/ethnicity. It is obvious that the essence of accountability, according to the NCLB, is accountability for subgroups, particularly subgroups which have been disadvantaged historically by their low income and minority status. It is therefore important to investigate the extent to which student performance on the 2002 HSA was determined by economic disadvantage and minority status, so that the HDOE may have a clear baseline picture by which it can judge how well Hawaii's public schools will be leveling the playing field from 2002 up to 2014 to ensure educational equity.

II. The Hawaii State Assessment (HSA) Reading Test

The HSA was designed years before the NCLB was authorized in 2001. As a response to the public's demand for accountability and the 1994 Improving America's Schools Act (IASA), the HDOE decided to reform its statewide testing program into a three-tiered standards-guided assessment system (Hawaii Department of Education Office of Accountability and School Instructional Support / School Renewal Group, 1999). Assessment is to be conducted at the classroom, school and state levels in accordance with the revised Hawaii Content and Performance Standards, known as HCPS II. Since

2001, the state-level assessment has become the primary instrument by which the HDOE intends to demonstrate compliance with the NCLB. For the purpose of this study, the HSA refers only to the state-level assessment. In spring, 2002, the new HSA reading and math tests were administered to grades 3, 5, 8 and 10. The present study reports analyses based on the 2002 reading tests.

The HSA reading tests are based upon four "strands" of standards:

1. Range - "Read a range of literary and informative texts for a variety of purposes including those students set for themselves."
2. Processes - "Develop and use strategies within the reading processes to construct meaning."
3. Conventions and Skills - "Develop and apply an understanding of the conventions of language and texts to construct meaning."
4. Response and Rhetoric - "Using individual reflection and group interaction, comprehend and respond to texts from a range of stances: personal, critical and creative." (Hawaii Department of Education Office of Curriculum Instruction and Student Support / Instructional Services Branch, 2003, pp. 14-16)

Each reading test consists of two types of items: selected response (multiple-choice) items and constructed response (short or extended answer) items that require writing (Hawaii Department of Education, 2001). All test items are matched with the second, third and fourth strands. Scaled total scores are classified into four performance levels: exceeding, meeting, approaching, and well below proficiency. The scaled total of 300 is set as the cutoff proficiency score. Any student scoring below 300 is considered to have failed to meet the expected proficiency level.

III. Research Questions

The objective of the present study is to examine the impact of three demographic variables, poverty, ethnicity and gender, on the risk of a student failing to meet the HSA proficiency standards in 2002, with the hope that follow-up research in subsequent years will point to an appreciable and steady decline in the negative impact of poverty and minority status on academic achievement, as compared with the 2002 baseline. The variable of gender has been included in the analyses because past research in Hawaii has consistently shown a gender difference in favor of girls in both language arts and math (e.g., Brandon & Jordan, 1994; Brandon, Newton & Hammond, 1987; Reiss, 2005). No reliable information is currently available from the HDOE database about other important demographic variables, such as length of residence in an English-speaking country, home language use, parent's educational attainment, family income relative to household size, etc. Therefore those variables have to be ignored in this research.

The present study addresses three specific research questions:

1. To what extent is HSA reading performance influenced by gender, poverty or ethnicity separately? This set of three univariate analyses provides an initial understanding of the impact of each of the demographic variables on the odds of a student failing to reach reading proficiency.

2. Is there a general pattern of the effects due to the three demographic variables across the grade levels? With the three predictors incorporated into one single predictive model for each grade level, would a generalizable predictive model, with or without interaction effects, emerge?

3. And finally, how accurate are the predictive models with respect to different racial/ethnic subgroups? Attention will be directed beyond an overall percent of correct classification to two other aspects of predictive accuracy: probability of false identification of failure and probability of false identification of pass. Such knowledge will help to adjust the understanding of the overall predictive model with respect to various racial/ethnic subgroups.

IV. Method

The dependent variable in this study is the binary variable of pass/fail (pass = 1, fail = 0). The event of failure (0) is modeled in logistic regression. More specifically, it is the log odds of failure, i.e., $\ln(p/(1-p))$, that is regressed on to the predictors. The letter p refers to a student's probability (risk) of failure. The ratio between the probability of failure, p, and the probability of pass, (1-p), is known as odds. The three independent variables are operationally defined below:

- gender (male = 0, female = 1)
- low-income status (ineligible for free or reduced price lunch = 0; eligible for free or reduced price lunch = 1)
- race/ethnicity (East Asian, Filipino, Hawaiian or White, dummy coded with the White group designated as the reference group)

For any statistically significant logistic regression coefficients, their profile likelihood odds ratios and the 95% confidence limits are reported (SAS Institute, 1995).

The data set has 9,257 third graders (75.35% of all third graders who took the HSA), 9,602 fifth graders (77.01%), 8,043 eighth graders (75.73%), and 6,504 tenth graders (71.72%). The student population in Hawaii is diverse to such an extent that all racial/ethnic groups, including Whites, are numerical minorities. The four largest racial/ethnic groups: East Asian (Japanese, Chinese and Korean), Filipino, Hawaiian, and White, constitute approximately three quarters of the student population. Those are the racial/ethnic categories that have been historically used in Hawaii educational studies.

Table 1

V. Results and Discussion

V.1. Research Question One

The failure rates by gender, low-income status, and ethnicity are reported in Table Two below.

Table 2

As expected, girls have a significantly lower failure rate than boys in reading across the grade levels, with statistically significant odds ratios of 0.73, 0.61, 0.54 and 0.49 for grades 3, 5, 8 and 10 respectively. In other words, the odds of failure for girls are 27%, 39%, 46% and 51% lower than boys at the four grade levels respectively. This single predictor model has an adjusted R-square (Nagelkerke, 1991) of 0.74, 0.75, 0.75, and 0.75 for Grades 3, 5, 8 and 10 respectively. It is not clear what exactly accounts for the persistent gender difference because gender can be interpreted as a composite of numerous biological, psychological and socio-cultural factors. However, this finding does have profound pedagogical implications if the HDOE is to be serious about ensuring that all students, boys as well as girls, attain the expected reading proficiency at each grade.

In the four grades examined, students eligible for free or reduced price lunch are found to have significantly higher failure rates than their ineligible peers, which is not at all surprising. The heavy and statistically significant odds ratios, 2.74, 2.62, 2.33, 2.09 for grades 3, 5, 8 and 10 respectively, are all against low-income students. Eligibility for free or reduced price lunch means more than double the odds of falling below the HSA standards. Those odds ratios suggest that poverty has a much stronger effect on academic success than gender. The univariate logistic model has an adjusted R-square of 0.75 for all the four grades.

Among the four racial/ethnic groups, East Asian and White have quite similar failure rates, which are clearly lower than those of the Filipino and Hawaiian groups. Compared to Whites, Filipino and Hawaiian students at all grade levels experience significantly higher odds of failure, whereas no statistical difference is found between East Asian and White students at any of the grade levels except grade three. The odds ratios for the Filipino vs. White contrast are 2.90, 2.40, 2.63, 2.70 for the four grades respectively; the odds ratios for the Hawaiian vs. White contrast are even greater, 3.38, 3.44, 3.60 and 3.59 for the four grades respectively. Hawaiians face nearly 3.5 times the odds of failing compared to Whites. The only statistically significant difference found between East Asians and Whites is an odds ratio of 0.84 at the third grade, indicating that East Asian children actually outperform their White peers. All this points to race/ethnicity as possibly the greatest influence among the three predictors – a possibility that is further confirmed by the findings resulting from the next research question. The adjusted R-square due to race/ethnicity remains 0.75 at all the four grade levels.

V.2. Research Question Two

Given three demographic predictors, the full logistic regression model can have seven effects: three main effects, three two-way interaction effects and one three-way interaction effect. When the full model was applied to the four grade levels, the three-way interaction effect was non-significant in all cases. This finding justified a subsequent search for more parsimonious predictive models. It may be in order here to add that this finding corroborates the conclusion of no need to consider a possible three-way interaction between gender, poverty and ethnicity, reached in several large scale studies (N > 1,000) that examined academic performance in math, reading and science (Bali & Alvarez, 2003; Derington-Moore, 2003; Gertz, 1999; O'Conner & Miranda, 2002; Patton, 2003; Saturnelli & Repa, 1995).

Further examination of the two-interactions revealed no consistent or interpretable patterns. So a decision was made to adopt a main-effects-only model for all the grade levels. The pattern of effects, in terms of direction, magnitude and accuracy in prediction, is similar enough to suggest that there may exist one single underlying model across the grade levels. The results are reported in Table Three.

Table 3.a-d

The three-predictor model can correctly classify 65.0%, 64.8%, 64.5% and 64.8% of the students into the "pass" or "fail" group at grades 3, 5, 8 and 10 respectively. In other words, without any consideration of academic capability, roughly 65% of the students' HSA results could be correctly placed. This is clear evidence that demographic variables beyond the control of the public education system are potent determinants of academic achievement in Hawaii. This demographics-based predictive model works in three ways, disadvantaging boys, poor students, and Filipino and Hawaiian students. Conversely, it favors girls, high-income students, and students of White or East Asian ancestry.

A significant gender effect in favor of females is consistent across the grades. Other factors being equal, girls' odds of failure may be 31% lower at grade three, 45% lower at grade five, 58% lower at grade eight, and 50% lower at grade ten. Gender appears to have a greater impact at the higher rather than lower grades.

A more powerful determinant than gender is eligibility for free or reduced price lunch. This eligibility translates into a 110% increase in the odds of failure at the third grade, 103% increase at the fifth grade, 58% at the eighth grade, and 75% at the tenth grade. Unlike the gender effect, its negative impact seems to weaken as the student gets older. Nonetheless, the magnitude of the odds ratio far exceeds the corresponding gender-related odds ratio at each grade level.

The most potent determinant is found to be race/ethnicity. Because poverty and race/ethnicity are correlated, there has been a long standing debate as to whether or not race/ethnicity is only a proxy for poverty (e.g., Abbot & Joireman, 2001; Harkreader & Weathersby, 1998; Williams, 1972). The analyses based on the HSA data show that race/ethnicity has a definitive unique effect, in spite of its correlation with the low-income status. Furthermore, as far as the contrasts between Whites on one hand and Filipinos and Hawaiians on the other are concerned, race/ethnicity seems to have a much more drastic influence than poverty. After the effect of poverty is controlled for, Filipino students' odds of failure are 122% higher than the Whites' at grade five. And that is the lowest odds ratio attributable to race/ethnicity. The most dramatic example is that Hawaiian students' odds of failure are 361% of the Whites' at the eighth grade. Such empirical evidence strengthens the argument that race/ethnicity impacts achievement over and beyond the effect of the associated variable of poverty (e.g., Bali & Alvarez, 2004; Brooks-Gunn, Duncan, & Klebanov, 1994; Lubienski, 2001). The three-effect logistic regression model has a stable adjusted R-square of 0.75 at all the grade levels examined.

Given the three demographic variables, there are 16 possible combinations at each grade level with a wide range of probabilities of failure. The contrasts between the subgroups least and mostly likely to fail (East Asian females without free lunch vs. Hawaiian males with free lunch) are 0.24 vs. 0.75, 0.24 vs. 0.78, 0.23 vs. 0.79, and 0.24 vs. 0.81 for Grades 3, 5, 8 and 10 respectively (Uyeno, Zhang & Chin-Chance, 2005). This is the picture the HDOE faced in 2002 as it began the arduous task to ensure all students and all schools meet the NCLB mandates by 2014.

In short, a general logistic model consisting of three main effects is adequately applicable to the four grade levels. The model can correctly classify about 65% of the students in each grade and maintain a fairly consistent pattern of significant effects due to gender, low-income status and ethnicity. Of the three effects, ethnicity appears to be the most powerful determinant, followed by low-income status and gender. This hitherto undocumented pattern of relative potency is consistent across the four grade levels in Hawaii.

V.3. Research Question 3

The last part of the study shifts attention to those students who are misclassified by the logistical model. Table Four reports the sensitivity and specificity of the model at each grade level. Sensitivity refers to the percentage of true failures identified by the logistic model, and specificity refers to the percentage of true successes identified by the model. Also included in the table are the probabilities of false failure and false success as identified by the logistic model.

Table 4

With the cutoff of predicted probability of failure set at 0.50, the predictive model, with all ethnicities/races considered together, shows a sensitivity of 0.64 at grade three, 0.65 at grade five, 0.69 at grade eight, and 0.62 at grade ten. Specificities are 0.67, 0.65, 0.61 and 0.68 for grades three, five, eight and ten respectively. Those indices remain fairly stable across the grades, providing further evidence for the feasibility of a general underlying logistic model across the grades.

The misclassified students at each grade level fall into two categories, those who are predicted to pass (not fail) but actually failed ("false negatives" henceforth); and those who are predicted to fail but actually passed ("false positives" henceforth). Although much research has been conducted relating academic performance to demographic variables, particularly low-income status and race/ethnicity, probabilities of false negatives or positives have not received much attention. In Hawaii, this neglect may be partly due to the fact that no viable pass/fail standards existed in public schools for years until the NCLB of 2001. In a more broad perspective, while the effects of social, cultural, and economic factors on academic attainment are widely accepted, it is rare to find carefully thought out empirical research on inaccuracies in inferring from such factors to individual achievement within subgroups. The NCLB's unambiguous requirement of fair and clear measures of subgroup performance prompted the third research question.

The racial/ethnic distribution of the false negatives deviates drastically from the expected proportions at each grade level (chi-square = 478, 436, 729 and 522 for grades 3, 5, 8 and 10 respectively; $df = 3$, $p < 0.001$ for all cases). For example, among the third graders, 37.63% of the 1,693 false negatives are East Asian students (significantly higher than the population proportion of 22.21%), and 29.36% are Whites (significantly higher than the population proportion of 19.13%). Obviously East Asian and White students in Hawaii's public schools would enjoy a better than deserved academic reputation, were such reputation to be based exclusively on the three demographic variables. On the other hand, Filipino and Hawaiian students would be more likely to be disparaged than their East Asian and White counterparts. About 14.06% of the negative falses are Filipinos (significantly lower than the population proportion of 31.95%, and 29.36% are Hawaiians (significantly lower the population proportion of 19.13). The observed probability of a false negative (predicted pass with an actual outcome of failure) being East Asian or White is 0.67 as compared to 0.33 for Filipinos or Hawaiians. The so-called academic success of East Asian and White students cannot be accurately interpreted unless more research attention has been devoted to the number of false negatives in theoretical or statistical models based exclusively on demographics. The over-representation of East Asians or Whites (67%, 66%, 75% and 73% for grades three to ten respectively), or under-representation of Filipino or Hawaiians, persists among the false negatives across the grades.

The other side of the story is of course that among the false positives, i.e., predicted failure with an actual outcome of pass, it is the Filipinos and Hawaiians who outnumber East Asians or Whites. For instance, of the 1,025 false positive tenth graders, 935 (91.22%) are Filipinos and Hawaiians. Only 90 (8.78%) are East Asians or Whites. This pattern is stable across the grades. The probability of an East Asian or White to pass who

is predicted to fail is only 0.10, 0.13, 0.10, and 0.09 for grades three to ten respectively. The overall percent of correct classification based upon the demographics does not tell the whole story. What is lost is the exciting news about the valiant efforts and personal victories of many, many educationally disadvantaged Filipino and Hawaiian students in Hawaii's public schools who manage to beat the heavy odds and meet or exceed the HSA proficiency level. Approximately 90% of the 1,543 false positives are Filipino or Hawaiian at the third grade; so are 87% of the 1,659 at the fifth grade, 90% of the 1,588 at the eighth grade, and 91% of the 1,025.

VI. Conclusion

The present study is limited by the absence of many other demographic variables that might conceivably have contributed to the failure rates on the 2002 HSA reading tests. It also faces the methodological challenge of how to include numerous smaller subgroups into the analyses. The predicted probabilities of failure used in classifying the students into the predicted pass and fail groups may be optimistically biased because the predicted results and the actual results are from the same data. Validations using 2003 and 2004 HSA data are under consideration.

Nevertheless, this research has provided the HDOE a preliminary overall understanding of what roles the major demographic variables of gender, low-income status, and race/ethnicity, played, individually and jointly, in determining students' reading performance in the NCLB baseline year of 2002. It has been found that one single main-effects-only logistic model is viable, correctly classifying approximately 65% of the students into the "pass" or "fail" group at each of the four grade levels examined. If the NCLB is to come anywhere near its stated overall objective, logistic regression coefficients associated with the demographic variables should all have decreased to a value near 0 by 2014 (odds ratio close to 1). Barring that, the HDOE may take heart in the hitherto undocumented success story that many educationally disadvantaged Filipino and Hawaiian students, with support from Hawaii's public education system, have proved to be capable of overcoming their odds of failure and reaching the HSA proficiency level.

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Table 1

Frequency Distribution of the Data

Grade	Ethnicity	Free Lunch? (Top Row=No Bottom Row=Yes)	% of Sample	Sample Size (per grade)	Total Usable Scores (per grade)
3	East Asian	1,661	0.18	9,257	12,285
		395	0.04		
	Filipino	1,310	0.14		
		1,162	0.13		
	Hawaiian	1,080	0.12		
		1,878	0.20		
	Caucasian	1,198	0.13		
		573	0.06		
5	East Asian	1,730	0.18	9,602	12,468
		390	0.04		
	Filipino	1,378	0.14		
		1,191	0.12		
	Hawaiian	1,173	0.12		
		1,894	0.20		
	Caucasian	1,305	0.14		
		541	0.06		
8	East Asian	1,653	0.21	8,043	10,620
		254	0.03		
	Filipino	1,329	0.17		
		893	0.11		
	Hawaiian	1,180	0.15		
		1,296	0.16		
	Caucasian	1,067	0.13		
		371	0.05		
10	East Asian	1,606	0.25	6,504	9,068
		185	0.03		
	Filipino	1,303	0.20		
		564	0.09		
	Hawaiian	956	0.15		
		695	0.11		
	Caucasian	983	0.15		
		212	0.03		

Table 2

Rates of Failure by Subgroups

	Grade 3	Grade 5	Grade 8	Grade 10
Study Sample	50.26	50.95	50.04	50.49
Gender				
Male	54.32	57.02	59.11	58.17
Female	46.28	44.70	41.45	41.83
Income Status				
Not receiving free lunch	39.61	41.12	43.70	45.26
Receiving free lunch	64.22	64.62	61.83	54.74
Ethnicity				
East Asian	30.98	33.96	33.14	32.89
Filipino	60.68	57.61	58.24	60.69
Hawaiian	64.27	66.03	64.98	67.84
Caucasian	34.73	36.13	34.08	36.99

Table 3

Regression Coefficients and Odds Ratio Estimates by Grade

Table 3a: Grade 3	Regression Coefficient	Odds Ratio	95% Profile Likelihood Confidence Limits	
Intercept	-0.70			
Gender (Ref = Female)	-0.37 **	0.69	0.63	0.75
Low Income Status (Ref = Not Receiving Free Lunch)	0.74 **	2.10	1.92	2.30
Ethnic Group (Ref = Caucasian)				
East Asian	-0.07	0.93	0.81	1.07
Filipino	0.99 **	2.70	2.37	3.07
Hawaiian	1.03 **	2.81	2.48	3.19

* $p < 0.05$

** $p < 0.001$

Table 3b: Grade 5	Regression Coefficient	Odds Ratio	95% Profile Likelihood Confidence Limits	
Intercept	-0.51			
Gender (Ref = Female)	-0.59 **	0.55	0.51	0.60
Low Income Status (Ref = Not Receiving Free Lunch)	0.71 **	2.03	1.85	2.22
Ethnic Group (Ref = Caucasian)				
East Asian	-0.03	0.97	0.85	1.11
Filipino	0.80 **	2.22	1.96	2.52
Hawaiian	1.07 **	2.91	2.57	3.30

* $p < 0.05$

** $p < 0.001$

Table 3c: Grade 8	Regression Coefficient		Odds Ratio	95% Profile Likelihood Confidence Limits	
Intercept	-0.40				
Gender (Ref = Female)	-0.86	**	0.42	0.39	0.47
Low Income Status (Ref = Not Receiving Free Lunch)	0.46	**	1.58	1.43	1.75
Ethnic Group (Ref = Caucasian)					
East Asian	0.02		1.03	0.88	1.19
Filipino	1.01	**	2.74	2.37	3.16
Hawaiian	1.28	**	3.61	3.13	4.17

* $p < 0.05$

** $p < 0.001$

Table 3d: Grade 10	Regression Coefficient		Odds Ratio	95% Profile Likelihood Confidence Limits	
Intercept	-0.30				
Gender (Ref = Female)	-0.70	**	0.50	0.45	0.55
Low Income Status (Ref = Not Receiving Free Lunch)	0.56	**	1.75	1.54	1.98
Ethnic Group (Ref = Caucasian)					
East Asian	-0.15		0.86	0.74	1.01
Filipino	0.95	**	2.59	2.22	3.02
Hawaiian	1.20	**	3.31	2.81	3.89

* $p < 0.05$

** $p < 0.001$

Table 4

Sensitivity Analysis by Ethnicity

		% Correct	Sensitivity (Correctly pred fail / total fail)	Specificity (Correctly pred pass / total pass)	Predicted Fail, Actual Pass	Predicted Pass, Actual Fail
East Asian	Grade 3	69.02	0.00	1.00	0.00	0.31
	Grade 5	68.26	0.17	0.94	0.04	0.28
	Grade 8	67.81	0.12	0.95	0.03	0.29
	Grade 10	68.01	0.10	0.96	0.03	0.29
Caucasion	Grade 3	63.18	0.19	0.87	0.09	0.28
	Grade 5	63.76	0.19	0.89	0.07	0.29
	Grade 8	66.00	0.19	0.90	0.06	0.28
	Grade 10	63.60	0.12	0.94	0.04	0.33
Filipino	Grade 3	61.48	0.79	0.35	0.26	0.13
	Grade 5	61.43	0.80	0.36	0.27	0.12
	Grade 8	60.26	0.76	0.39	0.26	0.14
	Grade 10	59.83	0.69	0.45	0.22	0.19
Hawaiian	Grade 3	66.36	0.87	0.28	0.26	0.08
	Grade 5	66.00	0.86	0.27	0.25	0.09
	Grade 8	64.98	1.00	0.00	0.35	0.00
	Grade 10	67.84	1.00	0.00	0.32	0.00