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EFFECTS OF EDUCATIONAL LEVEL ON PREDICTION OF TRAINING SUCCESS WITH THE ACB

Milton H. Maier

MILITARY SELECTION RESEARCH DIVISION

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13. ABSTRACT

The DIFFERENTIAL CLASSIFICATION Work Unit of the Behavior and Systems Research Laboratory has as a primary objective the continuing conduct of research to maintain and improve the effectiveness of the Army Classification Battery (ACB). As a part of the overall effort, a new ACB has been developed which results in improved measures of potential for various job areas. Data on the validity of the ACB were obtained from extensive research in which a battery of experimental tests and operational measures were tried out on about 25,000 men in over 100 Military Occupational Specialty (MOS) training courses. These data were utilized in research on the effectiveness of the ACB with enlisted men at the extremes of input population -- non-high school graduates and college graduates. This publication reports on a statistical analysis of educational level as it affects the prediction of enlisted performance in Army training courses.

Samples of the men at each of four educational levels were formed: non-high school graduation, high school graduation, some college, and college graduation. Using the Gulliksen-Wilks analysis of covariance, ACB test scores and final training course grades were analyzed for the various samples to determine whether the predictors are equally effective for the different educational groups.

Results of the present analysis suggest that for the less well educated, the ACB measures predict higher training performance than the individual is likely to achieve. On the other hand, the likely performance of the college graduate tends to be under-estimated. Findings further suggest that effectiveness in predicting training performance could probably be improved by including level of education in the aptitude area composites used in classification.

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FOREWORD

The DIFFERENTIAL CLASSIFICATION Work Unit applies psychological measurement methods to enable the Army to make best use of the different skills and aptitudes of its enlisted personnel through increasingly accurate and differentiated measures of individual potential. Research is conducted to maintain and improve the effectiveness of the Army Classification Battery and related techniques and of conditions which may interact with the classification tests and thus affect the basis for utilization of the enlisted input--changes in training programs and job content and environment, for example.

A new Army Classification Battery (ACB) has been developed which results in improved measures of potential for various job areas. The usefulness of the new ACB was established on about 25,000 men in over 100 Army training courses. The validity of the new ACB in such a variety of situations provides a stable base for determining interaction effects and estimating the impact of changed circumstances. Data obtained in the development of the new classification measures were utilized in research on the effectiveness of the ACB with enlisted men at the extremes of the input population--non-high school graduates and college graduates. The present publication reports on a statistical analysis of educational level as it affects the prediction of performance of enlisted men in Army training courses.

The entire research task is responsive to special requirements of the Deputy Chief of Staff for Personnel and the U. S. Continental Army Command, as well as to objectives of RDT&E Project 2Q062106A722, Selection and Behavioral Evaluation, FY 1972 Work Program.

J. E. UHLANER, Director
Behavior and Systems
Research Laboratory

EFFECTS OF EDUCATIONAL LEVEL ON PREDICTION OF TRAINING SUCCESS WITH THE ACB

BRIEF

Requirement:

To determine whether Army Classification Battery (ACB) scores are equally effective as predictors of success in Army training courses for enlisted input of different educational levels.

Procedure:

Using data from extensive research on the Army Classification Battery conducted on 25,000 enlisted men in over 100 Military Occupational Specialty (MOS) training courses, samples of men at each of four educational levels were formed: less than high school graduation, high school graduation, some college, college graduation. ACB test scores and final training course grades were analyzed for the various samples (using the Gulliksen-Wilks analysis of covariance which tests for equality of three conditions--standard error of estimate, slope of regression lines, and intercepts) to determine whether the predictors are equally effective for the different educational groups.

Findings:

For the less well educated, the ACB measures predict higher training performance than the individual is likely to achieve. The likely performance of the college graduate, on the other hand, tends to be underestimated.

Utilization of Findings:

The training performance of enlisted men could probably be predicted more effectively by including level of education in the aptitude area composites used in classification.

EFFECTS OF EDUCATIONAL LEVEL ON PREDICTION OF TRAINING SUCCESS WITH THE ACB

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EFFECTS OF EDUCATIONAL LEVEL ON PREDICTION OF TRAINING SUCCESS WITH THE ACB

BACKGROUND

The Army Classification Battery (ACB) has a long history of effective prediction of success of enlisted men in Army training courses, and there is no question about its validity for the full range of ability. The tests have proved valid in numerous studies conducted over a twenty-year period. During this time, however, possible differences in validity of the ACB for various subgroups of the input population have not been the explicit subject of investigation. Non-high school graduates and college students constitute significant subgroups of the Army population, especially since inauguration of Project 100,000 in which mental standards were lowered to accept men of lower ability and the revision of policy on induction of college graduates.

The American Psychological Association Task Force on Employment Testing of Minority Groups has urged that selection and classification tests be explicitly validated for groups that deviate from the cultural mainstream[1]. The present research was designed to help fill the information gap that exists about the predictive validity of the Army's paper-and-pencil aptitude tests for certain groups which fall in this category.

Determination of whether the ACB tests are equally appropriate for all educational subgroups lies in the regression of training performance on ACB test scores. If the regression is homogeneous, then the tests are equally effective as classification instruments for all subgroups. For the relationship to be the same for all subgroups, three statistical properties must be satisfied: 1) The standard errors of estimate must not be significantly different. 2) The slopes of the regression lines must be essentially parallel. 3) The intercepts of the regression lines must not be significantly different. These are the three assumptions tested in the analysis of covariance design.

In the context of Army enlisted classification, the standard errors of estimate are measures of how much variance in final course grades is unaccounted for after the effects of other variables--in this case, ACB test scores--have been statistically removed. If the standard errors are equal for all subgroups, then the accuracy of prediction is about the same for all subgroups; or, stated another way, the scatter of grades about the regression line is equal for all groups. The standard error of estimate, then, indicates to what extent final grades are a function of test scores. If the standard errors are different, then the grades are differentially predictable by the tests in the different groups.

1/ APA Task Force on Employment Testing of Minority Groups. Job testing and the disadvantaged. <u>American Psychologist</u>, 1969, 24, 637-650.

The second property to be examined is the equality of slope of the regression lines. The slope indicates how much improvement can be expected in criterion performance with a given increase in predictor score. If the regression lines for the various subgroups are all at the same angle, equal increments in predictor scores should result in equal changes in predicted criterion grades for all subgroups. An increase from, say, 100 to 120 for college graduates should result in the same amount of increase in predicted course performance as an increase from, say, 80 to 100 for school dropouts.

The final property is equality of intercepts; the intercept shows the height of the regression line. Equal scores on the predictor should result in the same expected course grade for all groups. If the intercepts are unequal, the same predictor scores result in different predicted grades for the various subgroups.

These three conditions, equality of standard errors of estimate, equality of slopes, and equality of intercepts, must be satisfied in order for test scores to have the same meaning for all subgroups. Lack of comparability across subgroups means that the indices are not operating in a consistent manner. Many reasons may account for the differences, and no a priori substantive meaning can be attached to any specific differences found. Any deviation from the operational assumptions of comparable validity should, however, be examined. The management decision may be to change the operational conditions or to live with the conditions which do not conform to the assumptions in the case of some subgroups. In any case, it is important to know how well reality conforms to the assumed conditions.

SCOPE OF THE PRESENT RESEARCH

In an another study, the construct validity of the Army Classification Battery in terms of intercorrelation patterns was examined for significant subgroups of the Army enlisted population[2]. A mechanical cluster and an academic cluster of tests were found for both non-high-school graduates and high-school graduates. However, no data were then available for a corresponding analysis of the predictive or criterion-related validity of the ACB. In the present research, the results of earlier work were extended to determine the validity of the ACB tests for predicting success of educational groups in Army training courses. The men were grouped according to level of education, and the validity of the ACB computed for each level of education.

[2] Maier, M. H. The effects of general ability, education, and racial group on aptitude test performance. Technical Research Note [illegible]. Behavior and Systems Research Laboratory, Arlington, Va. In press).

The Gulliksen-Wilks technique[3] was used to test the assumptions underlying the operational use of ACB test scores. The assumptions were tested in the order presented--equality of standard errors of estimate, slopes, and intercepts. With this model, an inequality with respect to one assumption means that the remaining assumptions cannot be tested. For the present analysis, if any one of the assumptions was found not to be tenable, then the regression lines would be examined visually to get estimates of the comparability in meaning of grades and test scores. While no tests of statistical significance could be made, operational implications could still be inferred from the regression lines.

METHOD

Data on the validity of the ACB were available from extensive research in which a battery of experimental tests was tried out[4]. Over 100 Military Occupational Specialty (MOS) training courses and about 25,000 men were included in the study. In the present analysis, for each MOS course or sample, a count was made of men at each educational level: 1) less than high school graduation, 2) high school graduation, 3) some college, and 4) college graduation. Only training course samples that contained more than 30 men in appropriate subgroups were retained. These samples are listed in Table 1. The seven samples in Set I had 30 or more scores at each of the four educational levels (except for the last sample listed which had only nine non-high school graduates and thus only three levels of education to be analyzed). The nine samples in Set II did not contain enough college graduates to treat as a separate group. The college graduates were combined with men who had attended college, and the combined group was termed "college trained". Thus, three levels of education were analyzed for the samples in Set II.

The data on each individual included the 11 test scores from the ACB and final course grade in the job training course. The test scores were obtained from official Army records; the grades were reported by the training installations.

The Gulliksen-Wilks analysis of covariance was performed in each sample to determine homogeneity of regression. In these tests, each of the three assumed conditions--equality of standard errors of estimate, of slopes, and of intercepts--is tested separately. A significant difference for any condition indicates a significantly different regression.

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[3] Gulliksen, H., and S. S. Wilks. Regression tests for several samples. Psychometrika. 1950, 15, 91-114.

[4] Maier, M. H. and E. F. Fuchs. The development of new aptitude area composites. Technical Research Report 1159 (AD 701 134). Behavior and Systems Research Laboratory, Arlington, Va. September 1969.

Table 1

NUMBER OF MEN AT EACH EDUCATIONAL LEVEL IN MOS SAMPLES

		Educational Level			
		Non HS Grad.	HS Grad.	Some College	College Grad.
	Set I MOS				
13E	Field Artillery Oper. & Intelligence Asst.	27	62	45	30
18C	Artillery Surveyor	32	218	233	30
70A	Clerk Typists	123	246	76	44
71H	Personnel Specialist	139	371	117	77
72B	Communication Center Specialist and Telephone Switchboard Operator	143	371	93	42
73A	Finance Clerk	29	227	127	40
73C	Disbursing/Examination Specialist and Accounting Specialist	9	214	125	39

		Non HS Grad.	HS Grad.	College Trained
	Set II MOS			
05C	Radio Teletypewriter Operator	92	262	91
11C	Light Weapons Infantryman and Indirect Fire Crewman	128	180	78
22J	Hawk Missile Repair and Fire Control Mechanic	81	148	34
31M	Radio Relay & Carrier Attendant	208	217	38
36C	Linemen	189	174	38
52B	Power Plant Operator Mechanic	144	135	44
63H	Engine & Powertrain Repairman	51	296	32
68G	Airframe Repairman	338	102	37.
91A	Medical Corpsman	181	145	36

RESULTS

The results of testing the homogeneity of regression are presented in Table 2 under the outcome heading. The standard errors of estimate are also shown. The standard deviation of final course grades and the multiple validity of the ACB are shown in the Appendix table. The regressions were significantly different in 13 of the 16 comparisons. In eight samples, the standard errors of estimate (SE_{est}) were significantly different; in one sample, the slopes were different; and in four samples the intercepts differed. In the eight samples in which the SE_{est} differed, there was a trend for the group with higher level of education to have the smaller standard errors of estimate. The largest standard errors were usually found in the groups of non-high school graduates.

The main finding that emerged from Table 2 was that the final course grades appear to have a different meaning for the college graduates than for the remaining examinees. The validity of the ACB was comparable to that of the other groups, but because of the smaller standard deviations of the grades, the standard errors of estimate were also smaller.

To obtain a graphic depiction of the ACB-course grade relationship, the mean final course grade and mean Arithmetic Reasoning test scores were plotted for each course (Figures 1 and 2). The grades in each sample were standardized to have a mean of 100 and a standard deviation of 20. The light lines in Figures 1 and 2 connect the means of individuals representing the four educational levels in each MOS training sample, and the heavy line in each figure connects the grand mean at each level. In most samples, both mean final course grade and mean Arithmetic Reasoning score were higher for the higher educational levels. Because of different grading practices, the samples differed in the spread of course grades among the various educational levels. The heavy lines connecting the grand means are relatively straight, indicating a linear relationship between mean test score and mean course performance when class means are used as the unit of observation.

The plots revealed some unsuspected facts about the grades. In each figure, mean course grades for the high-school graduates were clustered in a narrow band around 100, even though there was a large spread on the mean Arithmetic Reasoning test scores. Apparently, the performance of the high-school graduates is taken as the norm in these samples, regardless of aptitude level. College graduates in Figure 1 had the reverse situation. They were relatively homogeneous on mean test performance, but the course grades were divergent. The non-high school graduates showed a larger variation in both final course grade and Arithmetic Reasoning Test score. The some-college group in Figure 1 and the college-trained group in Figure 2 also had large variations in both grades and test scores. When the mean AR scores and course grades for the classes were plotted, there was virtually no relationship between mean final course grade and mean test score within an educational level, but the relationship was strong across educational levels.

Table 2

SUMMARY OF GULLIKSEN-WILKS ANALYSIS

Sample	Outcome[a]	Standard Error of Estimate Level of Education			
Set I		Non HS Grad.	HS Grad.	Some College	College Grad.
13E	SE est	3.9	5.0	4.5	3.3
18C	SE est	7.0	7.0	4.9	3.4
70A	SE est	5.0	5.7	5.6	4.2
71H	SE est	5.1	5.9	4.7	3.7
72B	Intercept	7.7	6.7	7.0	5.7
73A	SE est	3.6	7.1	8.9	5.0
73C	Equal	[b]	5.9	6.0	4.4
Set II		Non HS Grad.	HS Grad.	College Trained	
05C	Equal	5.8	6.2	6.0	
11C	Slope	5.2	5.9	5.5	
22J	Intercept	7.2	5.9	6.2	
31M	SE est	6.1	5.3	3.9	
36C	SE est	4.6	4.6	2.0	
52B	Intercept	4.2	3.7	3.0	
63N	Equal	2.3	2.5	1.5	
68G	SE est	2.4	3.8	3.0	
91A	Intercept	3.3	2.8	2.5	

[a] The outcome shows the results of the Gulliksen-Wilks tests:

SE est - The standard errors of estimate differed ($P < .01$)
Slope - The slopes differed ($P < .01$)
Intercepts - The intercepts differed ($P < .01$)
Equal - The regression lines did not differ significantly

[b] Non-High School Grads not included in analysis ($N = 9$)

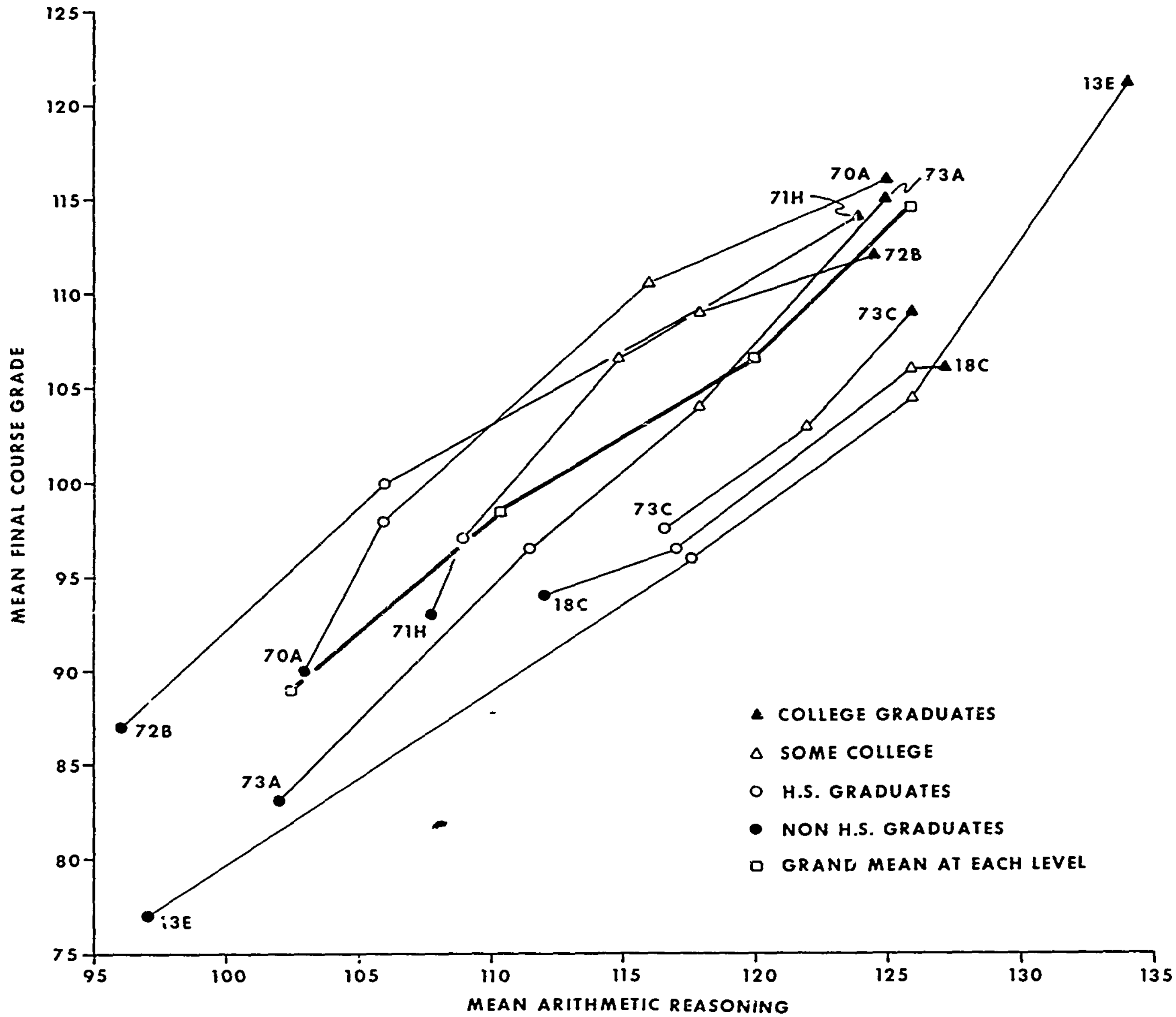
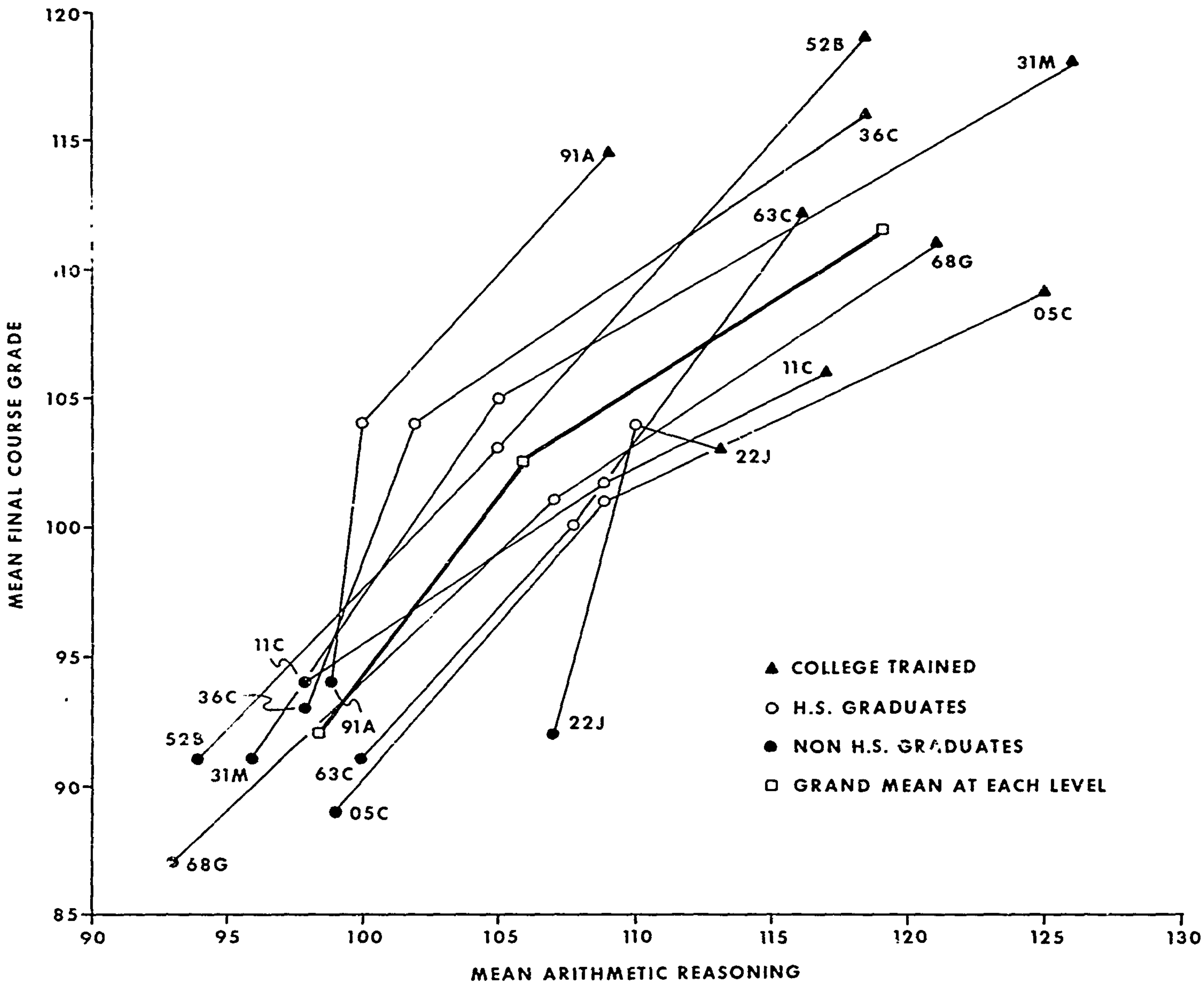


Figure 1. Mean Arithmetic Reasoning Score and Mean Final Course Grade for Samples in Set I.



Mean Arithmetic Reasoning Score and Final Course Grade for Samples in Set I.

The linear trend for the means suggested that the samples in each set could be pooled to form two large samples. The difference between the samples was primarily one of scaling of the course grades rather than one of linearity of relationship. The effect of pooling would be to increase the within-group error or to lower the correlation between the ACB and course performance. The samples in each set were pooled and the Gulliksen-Wilks analysis was performed for each pooled sample. The scatterplot of Arithmetic Reasoning Test scores versus grades was also obtained for each sample.

The results of the Gulliksen-Wilks analysis for the pooled samples are presented in Table 3. In both samples, the standard errors of estimate were significantly different at the 1 percent level. As was found for the individual samples, the standard deviations of the more highly educated groups were smaller than for those with less education. The ACB tests predicted course performance more accurately for the college trained men than for others. The slopes of the regression lines were parallel, as indicated by the regression lines for each educational level (Figures 3 and 4). This result means that a given increase in the ACB test scores results in the same proportional increase of predicted course performance for each of the educational levels. The intercepts, or heights of the regression lines, are clearly different for the groups, meaning that the same predictor score results in a different level of predicted course performance for the non-high school graduate as compared to the college graduate.

Some representative scores on the Arithmetic Reasoning Test were selected and the predicted course grades determined; the results are shown in Table 4. In Set I, the predicted course grades for the college graduates were consistently 10-17 points higher than for the non-high school graduates. An Arithmetic Reasoning Test score of 100 resulted in a predicted course grade of 105 for the college graduates and 88 for the non-high school graduates. The net result is that an Arithmetic Reasoning Test score of 120 for the non-high school graduates is comparable to a score of 80 for the college graduates. The predicted course grades are 96 and 97, respectively, in Set I and 100 and 98, respectively, in Set II. These results are consistent with prior research in the area. Helme[5] found that as the level of general mental ability declined, successively higher levels of aptitude test scores were required to produce the same level of predicted course performance.

DISCUSSION

Aptitude tests have enabled the Army to individualize the assignment of each soldier. Instead of treating all members of a group in the

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[5] Helme, W. H. Army school training performance of EM scoring low on AFQT. Technical Research Report 1140 (AD 60[illegible] 03[illegible]). Behavior and Systems Research Laboratory, Arlington, Va. October 1964.

Table 3

RESULTS OF GULLIKSEN - WILKS ANALYSIS OF POOLED SAMPLES

Group	Course Grades Mean	Course Grades Std dev	Multiple Correlation	Std Error of Est	N
		Set I			
Non-HS Grad.	89.0	19.0	.40	17.4	502
HS Grad.	97.9	18.9	.36	17.6	1653
Some College	106.3	18.7	.36	17.4	716
College Grad	114.7	16.2	.41	14.8	302
		Set II			
Non-HS Grad.	92.1	19.5	.42	17.7	1112
HS Grad.	102.4	18.7	.48	16.4	1659
College Trained	111.4	17.8	.42	16.2	428

Test for Equality

Hypothesis	df	χ^2	p
	Set I		
SE est	3	14.8	.005
Slope	33	23.6	—
Intercept	3	111.6	—
	Set II		
SE est	2	9.5	.01
Slope	22	33.1	.05
Intercept	2	66.6	.001

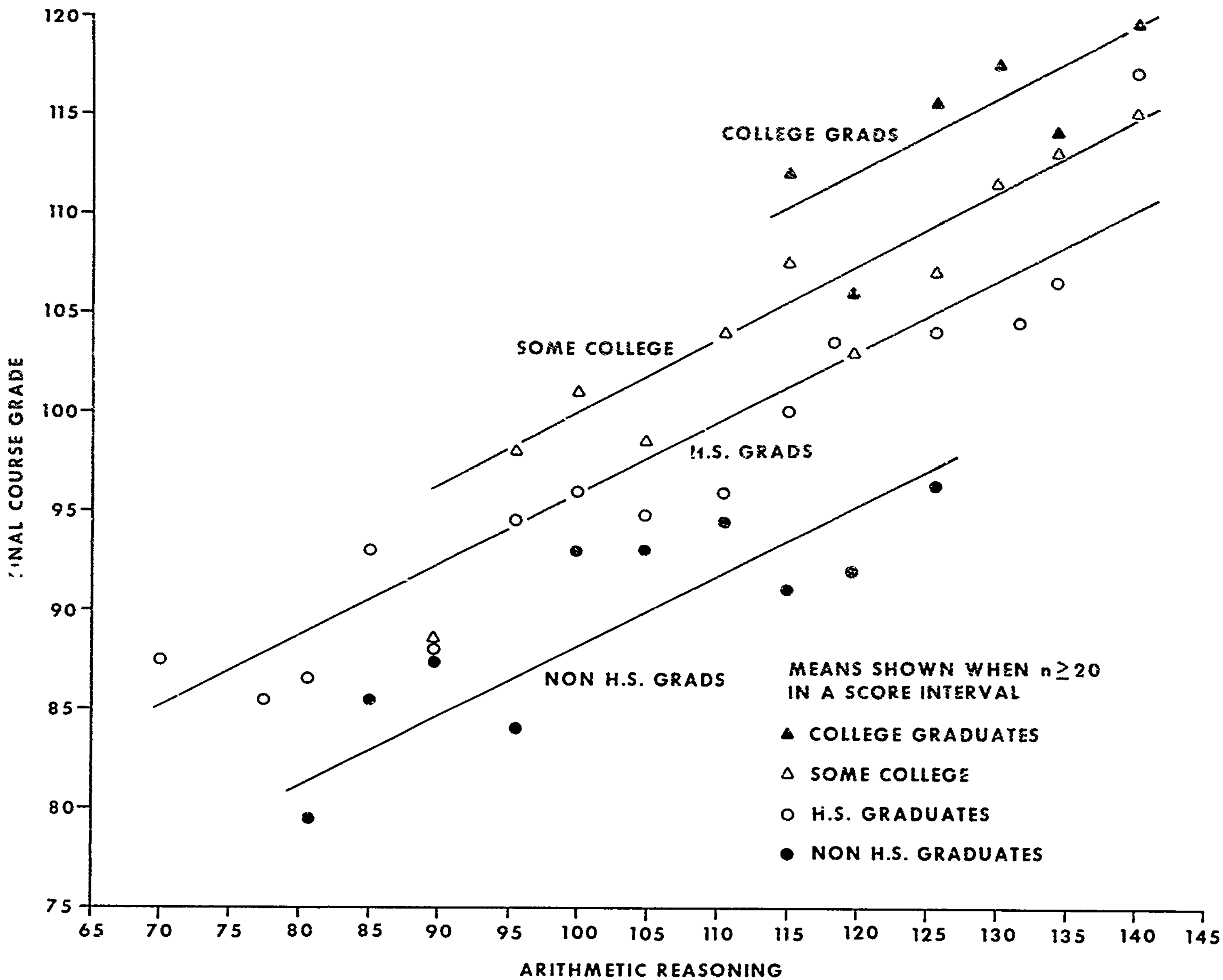

Figure 3. Regression of Final Course Grade on Arithmetic Reasoning for Pooled Sample, Set I.

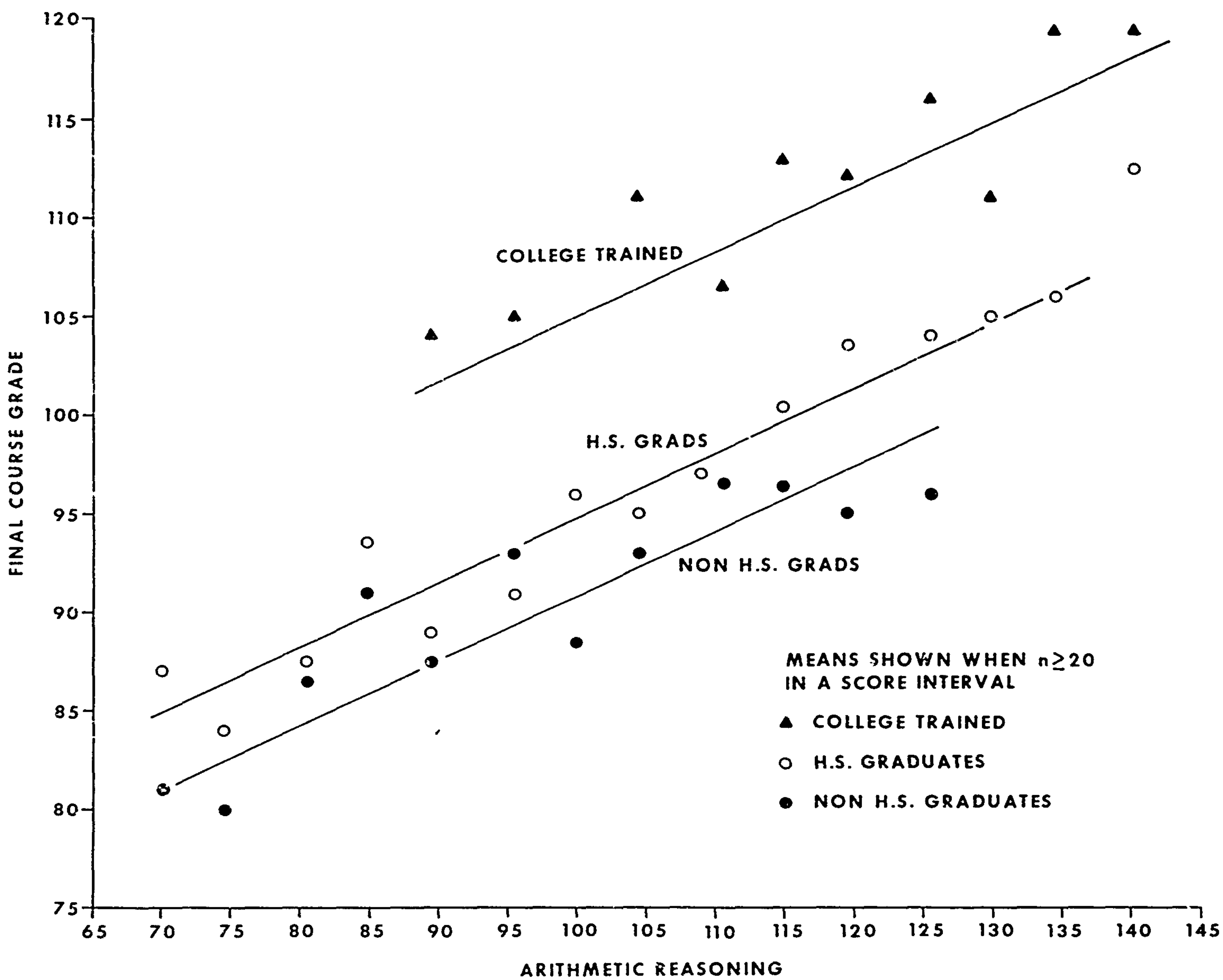

Figure 4. Regression of Final Course Grade on Arithmetic Reasoning for Pooled Sample, Set II.

same way, say, at random or in terms of civilian education or occupation, the aptitude tests provide personalized information about each man that can be used in making decisions about his training and assignment. In fact, the utility of test scores proved to be so great that other background information was not included in the aptitude area composites. The results of the present analysis suggest that the accuracy of the composites in assessing ability to perform could be improved by including background information about level of education.

One cost to the Army is that the course performance of the college graduate is consistently underestimated and that of the high-school dropout is overestimated, even though the college graduate typically starts out at a much higher level of aptitude test scores. A high-school dropout with a high test score, say 110, is likely to be assigned to a high level MOS. He is more likely to experience failure or marginal performance than is the high-school graduate with the same score.

The effectiveness of the ACB tests was determined by using success in training as the criterion. This criterion is a commonly accepted one, and it works to the benefit of both employer--in this case the Army--and the individual soldier. The Army benefits because the training resources are used more effectively, and the individual benefits because he is more likely to experience success.

Other outcomes besides success in training are of importance and need to be considered when policy decisions are made. For example, disadvantaged persons, according to one point of view, should be given compensatory treatment. Thus, even though their predicted performance may be low, these individuals could still be assigned to a highly technical MOS and then given specialized training. The outcome would then be measured by the skill level to which they could be trained. Ideally, then, in deciding how the aptitude area composites are to be used, the effects should be considered in the larger social context rather than in the limited context of predicting success in Army training.

A change in the aptitude area system has implications for selection, training, utilization, and retention. The results presented here were obtained under particular kinds of training programs. It is possible that different kinds of training programs could ameliorate some of the effects of educational deficit for some individuals. Or it is possible that jobs can be reengineered to reduce the number of technical tasks. The restructuring of training or jobs, or both, may have an effect on the validity of the aptitude area composites in relation to educational level.

The most important consideration arising from the research reported here is to call attention to the interaction between occupational area and educational level and between level of MOS and educational level and to raise questions about other possible interactions stemming from definable characteristics of special groups. Different bonus or penalty points for educational level may be required for different job areas or job levels, or both. Before the parameter values can be determined, large amounts of data would need to be obtained in a variety of situations for different groups. Since including background data in the classification system would have such pervasive social significance, the decisions should be made only on the basis of complete and accurate data.

Table 4

PREDICTED COURSE GRADES SHOWN BY EDUCATIONAL LEVEL

Predictor	Predicted Course Grades			
		Set I		
Arithmetic Reasoning Test Score	Non-HS Grad.	HS Grad.	Some College	College Grad.
80	80	87	92	97
100	88	94	99	105
120	96	100	105	112
		Set II		
Arithmetic Reasoning Test Score	Non-HS Grad	HS Grad.	College Trained	
80	84	90	98	
100	92	97	106	
120	100	106	112	

APPENDIX

APPENDIX

Table A-1

FINAL COURSE GRADES OF DIFFERENT EDUCATIONAL LEVELS

Set I

Sample	Means: Non-HS Grad	Means: HS Grad	Means: Some College	Means: College Grad	Standard Deviation: Non-HS Grad	Standard Deviation: HS Grad	Standard Deviation: Some College	Standard Deviation: College Grad	Multiple Correlation of Army Classification Battery: Non-HS Grad	Multiple Correlation of Army Classification Battery: HS Grad	Multiple Correlation of Army Classification Battery: Some College	Multiple Correlation of Army Classification Battery: College Grad
13E	69.8	[illegible]	82.3	90.1	6.4	7.4	7.8	5.2	.79	.74	.82	.78
18C	82.5	83.6	88.2	88.2	10.7	9.3	7.4	6.8	.76	.66	.75	.87
70A	74.7	78.2	83.2	86.5	7.2	7.6	7.8	5.3	.72	.66	.69	.62
71H	80.0	81.3	84.5	87.6	5.7	6.6	5.8	4.8	.44	.46	.59	.64
72B	79.6	85.6	89.4	91.1	8.9	8.0	8.8	7.8	.51	.55	.61	.68
73A	73.9	80.6	84.7	90.2	8.7	9.0	10.5	8.0	.91	.61	.53	.78
73C	a	83.4	85.6	88.0	a	7.7	7.2	7.9	a	.65	.56	.83

Set II

Sample	Means: Non-HS Grad	Means: HS Grad	Means: College Trained	Standard Deviation: Non-HS Grad	Standard Deviation: HS Grad	Standard Deviation: College Trained	Multiple Correlation of Army Classification Battery: Non-HS Grad	Multiple Correlation of Army Classification Battery: HS Grad	Multiple Correlation of Army Classification Battery: College Trained
05C	78.3	83.2	86.9	7.7	8.3	8.2	.66	.67	.68
11C	79.3	82.0	83.8	8.1	6.9	7.0	.77	.53	.61
22J	79.3	85.0	84.5	10.6	8.5	8.5	.73	.72	.68
31M	77.6	83.8	89.3	8.6	7.9	5.9	.70	.74	.75
36C	83.6	87.1	90.8	6.2	5.8	4.8	.67	.60	.91
52B	75.3	79.3	84.8	6.2	5.8	4.6	.73	.77	.76
63H	74.9	76.9	79.6	4.2	4.1	3.9	.83	.80	.92
68G	70.0	74.6	77.8	5.9	6.3	4.4	.91	.89	.74
91A	81.5	83.4	85.4	3.5	3.6	3.6	.32	.63	.72

[a] Non-HS graduates not included in analysis (N = 9).

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