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CRITERION DEVELOPMENT FOR 18 TECHNICAL TRAINING SCHOOLS IN THE NAVY, ARMY, AND AIR FORCE

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The Navy Personnel Research and Development Center (NPRDC) and its contractor have collected data to evaluate the predictive validity of a joint-service battery of experimental computerized aptitude tests, referred to as Enhanced Computer Administered Tests (ECAT). To evaluate the validity of a test, the contractor has collected two types of data: 1) test scores on the predictor tests, and 2) data on the criterion measures of training school performance data.

For the criterion data, for each specialty, the types of school performance data vary, as well as the data's usefulness as a criterion measure. For this reason, we analyzed a sample of available school performance data, giving special attention to identifying any types of measures that tend to correlate highly with on-the-job performance, such as simulator or hands-on training in the laboratory. Then we combined measures that correlated highly with each other into summary scores, and determined reliabilities of the criteria. This report documents all procedures and analyses, and it provides the scientific justification for the criterion measures.

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INTRODUCTION

Research laboratories for the military have been exploring the potential of using new types of tests in military selection and classification. For more than the last five years, the Navy Personnel Research and Development Center (NPRDC) has focused on developing new computerized ability tests. These tests measure abilities that are not measured by the Armed Services Vocational Aptitude Battery (ASVAB), currently used for selection and classification of military applicants. NPRDC has explored over 30 tests and developed an experimental battery. They have also included some of these tests in a joint-service battery. NPRDC and its contractor have been collecting data to evaluate the predictive validity of this joint-service battery, referred to as Enhanced Computer Administered Tests (ECAT).

To evaluate the validity of a test, the contractor has collected two types of data: 1) test scores on the predictor tests, specifically, the new computerized tests, the CAT-ASVAB and the P&P-ASVAB, and 2) data on the criterion measures or training school performance data. Collection of predictor data involved giving selected examinees the same tests under standardized conditions. However, for the criterion data, for each specialty, the types of school performance data vary, as well as the data's usefulness as a criterion measure. For this reason, under Contract N66001-87-D-0010 delivery orders 7J13 and 7J17, we conducted criterion development. We analyzed a sample of available school performance data, giving special attention to identifying any types of measures that tend to correlate highly with on-the-job performance, such as simulator or hands-on training in the laboratory. Then we combined measures that correlated highly with each other into summary scores, determined reliabilities of the

criteria, and delivered the findings in the form of technical reports. However, school curricula changed over the course of data collection, and the Government needed further information to conduct the analyses and to justify the approach in joint-service reviews.

This report documents all procedures and analyses, and it provides the scientific justification for the criterion measures. We examined the following 13 Navy schools: Air Traffic Controller (AC), Aviation Electrician's Mate (AE), Aviation Ordnanceman (AO), Aviation Structural Mechanic - Structures (AMS), Avionics Technician (AV), Electrician's Mate (EM), Electronics Technician, Advanced Electronics Field (ET, AEF), Engineman (EN), Fire Controlman (FC), Gunner's Mate - Phase 1 (GMG), Machinist's Mate (MM), Operations Specialist (OS), and Radioman (RM). We also examined three Army schools: Heavy Antiarmor Weapons Crewman (11H), Field Artillery Fire Support Specialist (13F), and Tank Crewman (19K); and two Air Force schools: Air Traffic Control Operator (27230), and Personnel Specialist (73230).

APPROACH

Site Visits

As part of an earlier study, RGI researchers conducted site visits at the various schools (Kieckhaefer, Bebb, Crowe, Corpe, & Zultner, 1990; Kieckhaefer & Brantner, 1990). In these visits and in subsequent follow-up questions, researchers focused on: (a) identifying as much psychometric information about existing tests (including and especially test reliability information), (b) identifying as many performance or practical tests as possible, (c) formalizing informal grading and grade-recording systems whenever possible, and (d) determining the existence or extent of criterion contamination due to instructor knowledge of trainee predictor scores.

RGI researchers toured the training facilities which focused on the laboratories, simulators, and other hands-on performance-measurement situations. The researchers used these tours to: (a) gain an understanding of the kinds of skills required to perform successfully, (b) gain an understanding of the measurement techniques implemented by the school, and (c) identify any new performance measures to include in the study.

The current study examined the 18 schools listed in Table 1.

Table 1

Navy, Army, and Air Force Schools and Their Abbreviations

Service	School	Abbreviation
Navy	Air Traffic Controller	AC
	Aviation Electrician's Mate	AE
	Aviation Structural Mechanic - Structures	AMS
	Aviation Ordnanceman	AO
	Avionics Technician	AV
	Electrician's Mate	EM
	Electronics Technician, Advanced Electronics Field	ET
	Engineman	EN
	Fire Controlman	FC
	Gunner's Mate - Phase I	GMG
	Machinist's Mate	MM
	Operations Specialist	OS
	Radioman	RM
Army	Heavy Antiarmor Weapons Crewman	11H
	Field Artillery Fire Support Specialist	13F
	Tank Crewman	19K
Air Force	Air Traffic Control Operator	27230
	Personnel Specialist	73230

Data Analyses

Under Delivery Order 7J03, RGI entered the data for each case from all schools into a database (either from ISS tape or by manual data entry). We then implemented the same approach to data analysis for each data set. We used SPSSx as the statistical package software throughout the data analysis process. As the first step, we conducted descriptive data analyses using the SPSSx FREQUENCIES procedure to obtain univariate statistics (mean, standard deviation, skewness, kurtosis, minimum, and maximum) on each variable. We eliminated variables which had little or no variance and also variables which had substantial missing data.

During the next step, we conducted factor analysis. The researchers excluded from the factor analysis variables that consisted of linear combinations of other variables. For example, final school grade (FSG) consists of weighted test scores, and the researchers did not include FSG in any factor analyses. Then, we implemented a modified principal factoring procedure (principal axis factor analysis) such that we replaced the main diagonal elements of the correlation matrix with initial communality estimates given by squared multiple correlations.

Next, we ran a scree test to determine how many factors to extract (Cattell, 1966). We extracted only that number of factors identified by the scree test, provided that the resulting solution gave interpretable factors. Generally, we eliminated doublets, factors defined by only two variables (Harman, 1976, p. 129). The researchers followed this analysis with a varimax rotation. Finally, we computed and saved factor scores for each rotated factor.

Next, we computed several other variables. If training curricula had phases and factor analysis showed only one factor, researchers computed phase variables. If training had both written and performance tests, we computed

separate variables for each. If two or more factors resulted from factor analysis, then we computed simple sums of appropriate variables in addition to the factor scores.

At this point, we took steps to identify the fewest number of unidimensional criterion variables which would account for the criterion variance in each school. While criterion unidimensionality may lead to the inclusion of more criterion variables, the researchers considered this quality important in facilitating interpretation of results. With a multidimensional criterion, incremental validity demonstrated by one predictor may result from only one of the unidentified dimensions which make up the criterion. With a unidimensional criterion, the incremental validity demonstrated by one predictor battery over another shows clear evidence of superiority.

As the final step in identifying criterion variables, researchers obtained a correlation matrix of all factor scores, composite variables, and the official final school grade. With the objective of selecting the fewest unidimensional criteria, we used the evidence provided by these data to recommend criterion variables to include in the validity studies. We then obtained descriptive statistics on the recommended criterion variables.

As the final step in data analysis, researchers developed estimates of criterion reliability. The recommended criterion variables constitute combinations (or composites) of the tests administered in training. Hence, researchers developed reliability estimates of each component test first, and then combined those estimates appropriately to obtain a reliability estimate for the composite criterion variable. See Appendix A for detailed computational procedures for finding composite reliability and an illustrative example.

In all cases where researchers collected data, the communality estimates

provided by the factor analyses served as an estimate of reliability. For those few schools supported by the ISS system in Millington, TN, researchers could also obtain Kuder-Richardson estimates as a second estimate of test reliability. That system used the KR-20 formula to provide estimates for each version of the tests used in the school. In these cases, researchers determined the median KR estimate for each test and proceeded to combine reliability estimates for the composite. In these few cases, this provided a second (and generally higher) reliability estimate for the composite criterion variable. The researchers did not correct reliabilities for range restriction.

Statisticians consider the factor analytic procedure described above exploratory factor analysis. The researchers considered but did not do confirmatory factor analysis for two primary reasons. First, while previous researchers (Kieckhaefer et al., 1990; Kieckhaefer & Brantner, 1990) did some work in this area, the earlier studies used small sample sizes. Without a firm theoretical or empirical rationale for postulating a given factor structure and without specific hypotheses to test, the present researchers thus conducted exploratory factor analysis. We selected principal axis factor analysis for its variance maximizing properties and its specification of the relationship of communality to reliability. The second reason for exploratory factor analysis concerns the substantial curriculum changes that took place in many of the schools. These changes argued against any *a priori* expectation of a specified factor structure. To maintain consistency in their approach across all schools, even ones which had not changed, the researchers implemented the same procedure in all cases.

In schools which had a change in curriculum or testing plan, we treated the two or more curricula separately. We conducted multivariate analysis of variance

(MANOVA) on the criterion variables to assess differences in means and covariance matrices between curricula. We also conducted multivariate analysis of covariance (MANCOVA) on the criterion variables controlling for ability as assessed by pre-enlistment ASVAB scores.

To further evaluate differences between versions, we computed effect sizes as measures of the practical significance of the differences between the unadjusted means across curricula. We used the formula:

$$d = \frac{|M_A - M_B|}{\sigma},$$

where M_A is the mean of Group A on the variable of interest, M_B is the mean of Group B, and σ is the estimated population standard deviation (Cohen & Cohen, 1977). Cohen and Cohen (1977) say that .2 represents a small effect size, .5 is medium, and .8 is large. Thus, while the MANOVA tests may indicate that curricula differ from one another in terms of statistical significance, the effect sizes represent the degree of the differences in standard deviation units.

Finally, we also compared factor solutions from two or more curricula using the coefficient of congruence (Cattell, 1978; Gorsuch, 1983) to assess the resemblance of factors from one curriculum to those from another.

FINDINGS

The data collection and analyses described in the Approach section resulted in the findings and recommended criterion variables described in this section. First, the researchers describe the tests used in the various Navy, Air Force, and Army schools. As a minimum, they recommended including the FSG for each school. This recommendation stems from political reasons as well as because previous validity studies tended to use at least (if not only) FSG.

The subsections below present RGI's recommended criterion variables for each school. As noted above, RGI estimated reliability from the communality estimates in the factor analyses. Appendix A contains the detailed computational procedures for finding composite reliability and an illustrative example.

Navy Schools

Air Traffic Controller (AC)

Descriptions of Variables. The Navy Air Traffic Control (AC) School consists of three blocks: I. Base Operations, II. Tower, and III. Radar. Table 2 below lists the tests which make up each Block and the weights which the school assigns to each test in calculating the Final School Grade (FSG). The written tests have a (W) following their description, and the performance (laboratory) tests have a (P) following their description. The school scores all these tests and FSG on a scale from 0 to 100.

The school defines FSG as the weighted sum (composite) of the individual tests. Percentages representing the weights applied by the school to each test score in composing the FSG follow the test descriptions in Table 2. Students having initial test scores below 70 retake the test. For students who pass the first or subsequent retest, the school records scores of 70 and uses these scores in calculating the FSG. RGI entered the initial test scores in the database. Therefore, an FSG which a researcher might calculate using the initial scores differs from the FSG calculated by the school using the retest scores.

The Student action code/Status variable describes the category of student outcome (e.g., graduated, disenrolled; see Appendix B). The class convening date gives the year, month, and day the class started. The Block II (Tower) Airman's Written Test constitutes a Federal Aviation Administration (FAA) secure test. In Block III, students take an Identification & Vectoring Procedures performance test in a radar lab simulator. Instructors grade students on a Satisfactory ("S") or Unsatisfactory ("U") basis. Students who fail undertake remedial training, and reportedly all students pass the retest. RGI entered only the initial scores.

Table 2
Descriptions of AC Variables

Block	Test[a]		Weight
I	Air Traffic Control Fundamentals (W)		5%
I	Airspace & Time (W)		5%
I	Navigational Aids (W)		5%
I	Charts & Publications (W)		5%
I	Flight Plans (W)		5%
I	Aviation Weather (W)		5%
	Block I subtotal	30%	
II	Basic Knowledge (W)		5%
II	General Control & Equipment (W)		5%
II	Visual Flight Rules Procedures (W)		5%
II	Instrument Flight Rules Procedures (W)		5%
II	Airman's Written Test Certification (W)		10%
II	Local. Ground. Flight Data (P)		10%
	Block II subtotal	40%	
III	Identification & Vectoring Procedures (W)		5%
III	Identification & Vectoring Procedures (P)		0%
III	Air Surveillance Radar Procedures (W)		2.5%
III	Air Surveillance Radar Procedures (P)		5%
III	Precision Approach Radar Procedures (W)		2.5%
III	Precision Approach Radar Procedures (P)		5%
III	Arrival Procedures (W)		5%
III	Arrival Procedures (P)		5%
	Block III subtotal	30%	
	Final School Grade	100%	

[a]Key to letters in parentheses: W = Written tests. P = Performance or laboratory tests

The school provided information on students' rank and the number of students in the class, each of which could range from 1 to 30. We computed a measure of class standing using student rank (r) and class size (n): (class size - rank)/class size = (n-r)/n. The class standing variable puts students on a metric of 0 to approaching 1, so that the higher the standing, the better the student did relative to the other members of the class. Further, this measure takes into account class size. For example, a person who ranked first out of a class of 30 would have a standing of .97, while a person who ranked first out of a class of 5 would have a standing of .80.

Sample. We dropped cases which had missing data on any of the test variables. This resulted in a total sample size of N=81 out of an initial sample

of N=111. Then, we analyzed the 20 variables shown in Table 3.

Results and Discussion. Table 3 displays descriptive statistics on the AC tests. Factor analysis indicates three factors. Due to the small sample size, we present these results as suggestive and not definitive. Table 4 shows the communalities, factor loadings, and factor score coefficients. The primary factor consists of the sum of all the written tests, except the Precision Approach Radar Procedures written test which loads more heavily on the third factor. Thus, the major factor represents the knowledge the student has regarding the subject matter of Navy Air Traffic Control covering base operations, towers, and radar.

Table 3
Descriptive Statistics for AC Variables

Test[a]	Mean	Std Dev	Skew	Kurtosis	Minimum	Maximum
Air Traffic Control Fund. (W)	87.315	7.713	-.342	-.632	70.000	100.000
Airspace & Time (W)	82.975	9.624	-.246	-.395	55.000	100.000
Navigational Aids (W)	83.352	9.919	-.243	-.710	58.000	100.000
Charts & Publications (W)	84.226	8.033	-.398	.048	58.000	98.000
Flight Plans (W)	86.278	8.582	-.765	.928	57.500	100.000
Aviation Weather (W)	81.737	8.584	-.333	-.585	62.000	97.100
Basic Knowledge (W)	80.290	10.512	-.484	-.046	51.100	100.000
General Control & Equipment (W)	80.226	7.905	-.248	.418	58.000	100.000
Visual Flight Rules Procedures (W)	78.986	9.235	-.035	-.461	60.000	98.800
Instrument Flight Rules Proc. (W)	79.037	8.815	-.015	-.718	60.000	96.000
Airman's Written Test Cert. (W)	79.000	6.243	-.098	.621	60.000	96.000
Local, Ground, Flight Data (P)	89.725	5.487	-.409	-.071	73.300	100.000
Ident. & Vectoring Proc. (W)	82.432	8.540	-.128	-.222	60.000	100.000
Ident. & Vectoring Proc. (P)	.877	.331	-2.333	3.528	.000	1.000
Air Surveillance Radar Proc. (W)	85.864	9.513	-.589	-.225	60.000	100.000
Air Surveillance Radar Proc. (P)	90.654	8.469	-.993	.810	60.000	100.000
Precision Approach Radar Proc. (W)	85.123	9.649	-.603	.294	55.000	100.000
Precision Approach Radar Proc. (P)	93.043	7.285	-2.306	7.355	58.000	100.000
Arrival Procedures (W)	86.481	7.744	-.539	-.169	65.000	100.000
Arrival Procedures (P)	86.284	14.157	-3.161	16.405	.000	100.000

Note. N = 81.
[a]Key to letters in parentheses: W = Written tests, P = Performance or laboratory tests

Table 4
Communalities, Factor Loadings and Factor Score Coefficients for AC Variables

Variable	Communality	Factor Loadings			Factor Score Coefficients		
		1	2	3	1	2	3
Air Traffic Control Fund. (W)	.528	.714	-.133	-.004	.104	-.193	-.064
Airspace & Time (W)	.604	.776	.024	-.034	.180	-.029	-.013
Navigational Aids (W)	.527	.717	-.007	-.110	.119	-.020	-.146
Charts & Publications (W)	.580	.686	-.023	-.330	.135	-.126	-.295
Flight Plans (W)	.456	.619	-.072	.260	.067	-.079	.137
Aviation Weather (W)	.502	.705	-.004	.076	.102	-.084	.048
Basic Knowledge (W)	.596	.743	.093	.187	.132	.026	.138
General Control & Equipment (W)	.465	.675	.054	.075	.074	-.003	.021
Visual Flight Rules Procedures (W)	.568	.723	.200	.078	.108	.091	.031
Instrument Flight Rules Proc. (W)	.589	.727	.204	.136	.147	.128	.124
Airman's Written Test Cert. (W)	.403	.620	.105	.083	.060	.008	.017
Local, Ground, Flight Data (P)	.546	.263	.370	-.583	.029	.264	-.490
Ident. & Vectoring Proc. (W)	.181	.353	.202	.127	.024	.065	.080
Ident. & Vectoring Proc. (P)	.043	.029	.009	.205	.005	.023	.075
Air Surveillance Radar Proc. (W)	.217	.327	.276	.184	.002	.110	.059
Air Surveillance Radar Proc. (P)	.356	.023	.596	-.028	-.052	.366	-.027
Precision Approach Radar Proc. (W)	.326	.335	.189	.422	.008	.122	.224
Precision Approach Radar Proc. (P)	.161	-.090	.385	-.068	-.019	.157	-.020
Arrival Procedures (W)	.372	.563	.235	.012	.052	.071	.024
Arrival Procedures (P)	.243	.129	.469	.083	-.011	.199	.098

The second factor consists of the performance tests, except the Identification and Vectoring Procedures performance test, which loads on none of the factors and has a low communality (.043). The Local, Ground, and Flight Data performance test also loads more on Factor 3 than Factor 2. Thus, the second factor represents a skills dimension, assessed by student performance on the lab tests.

The third factor contrasts the Precision Approach Radar Procedures written test with the Charts and Publications written test and the Local, Ground, and Flight Data performance test. Factor 3 highlights the discrepancy between written knowledge of using radar for aircraft approaches versus written knowledge of charts and publications and performance in the Local, Ground, and Flight Data labs.

To clarify some of the ambiguity in the above factors, a forced two-factor solution yielded the written tests defining the first factor and the performance tests (except Identification and Vectoring Procedures) defining the second. However, the loading of the Local, Ground, and Flight Data lab on the second factor of this two-factor solution was considerably lower compared to the three-factor solution, thus, the empirical results favor three factors. The drawback of the third factor concerns its variables overlapping with Factors 1 and 2. A subject matter expert at the AC school could not interpret this third factor. While this Factor 3 may have significance, this overlap and the interpretability problem lead the researchers to defer recommendations of this factor.

The researchers developed composite variables to represent the dimensions uncovered by the factor analysis. "Knowledge" consisted of the mean of all 15 written tests. "Skills" consisted of the mean of the four performance tests (except the pass-fail Identification and Vectoring Procedures lab). "Contrast" consisted of (the Precision Approach Radar Procedure written test - Charts and Publications - Local, Ground, and Flight Data)/3. "Block I" consisted of the mean of all six Block I (Base Operations) tests. "Block II" consisted of the mean of all six Block II (Tower) tests. "Block III" consisted of the mean of all seven Block III (Radar) tests. Table 5 lists descriptive statistics on the composite variables.

Next, we computed Pearson correlation coefficients for the composite variables. Table 6 displays the intercorrelations among the composite variables and the factors. Since FSG and FSG2 correlate .96, this offers no support for using initial test scores to compute FSG.

The Knowledge composite correlates .98 with Factor 1, while the Skills composite correlates .88 with Factor 2. The Knowledge and Skills composites

Table 5
Descriptive Statistics for AC Composite Variables

Composite	Reliability[a]	Mean	Std Dev	Skew	Kurtosis	Minimum	Maximum
Knowledge[b]	.91	82.922	5.733	.398	-.655	71.413	98.473
Skills[c]	.59	89.926	5.861	-1.779	6.833	60.500	99.500
Contrast[d]	.59	-29.609	4.898	.431	.510	-39.567	-13.767
FSG	N/A	84.701	4.579	.396	-.519	74.530	97.450
FSG2[e]	.90	84.338	4.764	.422	-.606	74.780	97.450
Block I[f]	.87	84.397	6.697	.180	-.713	69.767	99.183
Block II[g]	.84	81.211	5.889	.373	-.728	71.250	97.033
Block III[h]	.63	87.126	5.074	-.866	2.406	66.000	97.214
Standing[i]	N/A	.441	.278	.173	-1.177	.000	.930

Note: The researchers did not include the Block III Identification & Vectoring Procedures performance test in any of the above composites. The researchers used the means of the various tests rather than the sums to keep them on the same 0-100 metric as FSG.
[a]These are composites based on communality estimates and the procedures described in the text.
[b]Knowledge: Mean of all Written Tests
[c]Skills: Mean of all Performance Tests
[d]Contrast: (PARPW - CP - LGFD)/3
[e]FSG2: FSG computed using initial test scores
[f]Block I: Mean of Block I (Base Operations) Tests
[g]Block II: Mean of Block II (Tower) Tests
[h]Block III: Mean of Block III (Radar) Tests
[i]Standing: Standing = (class size - rank)/class size

Table 6
Correlations Among AC Composites and Factors

Composite	Factor 1	Factor 2	Factor 3	Knowledge	Skills	Contrast	FSG	FSG(2)	Block I	Block II	Block III
Factor 2	.05										
Factor 3	.02	-.04									
Knowledge[a]	.98	.18	.16								
Skills[b]	.12	.88	-.15	.20							
Contrast[c]	-.26	-.00	.85	-.13	-.12						
FSG	.91	.36	-.00	.94	.39	-.31					
FSG2[d]	.94	.38	.03	.96	.44	-.22	.96				
Block I[e]	.96	-.05	-.04	.92	.10	-.30	.85	.87			
Block II[f]	.93	.28	.06	.93	.26	-.21	.90	.94	.80		
Block III[g]	.44	.79	.26	.59	.77	.16	.67	.70	.36	.53	
Standing[h]	.84	.36	.04	.88	.40	-.22	.90	.90	.80	.83	.69

Note: The researchers did not include the Block III Identification & Vectoring Procedures performance test in any of the above composites.
[a]Knowledge: Mean of all Written Tests
[b]Skills: Mean of all Performance Tests
[c]Contrast: (PARPW - CP - LGFD)/3
[d]FSG2: FSG computed using initial test scores
[e]Block I: Mean of Block I (Base Operations) Tests
[f]Block II: Mean of Block II (Tower) Tests
[g]Block III: Mean of Block III (Radar) Tests
[h]Standing: Standing = (class size - rank)/class size

assess relatively independent aspects of Air Traffic Controller school performance (r = .20). FSG correlates .94 with Factor 1 and only .38 with Factor 2. Knowledge correlates .96 with FSG, while Skills only correlates .44 with FSG. Thus, FSG largely reflects written test scores, as indicated by the preponderance of such tests in the AC school.

The measure of Base Operations (Block I) correlates most closely with Factor 1 (r = .96), as does the Tower (Block II) measure (r = .93). The Radar measure (Block III) correlates most closely with Factor 2 (r = .79). The correlations between these block measures and the Knowledge and Skills composites also reflect these patterns. Thus, Blocks I and II primarily measure written test ability and Block III primarily assesses lab performance. Finally, Standing correlates very highly with Factor 1 (.84), Knowledge (.88), and FSG (.90), which again reflects the prevalence of written test scores in this school.

Recommendations. In addition to FSG, use the mean of the four performance tests, excluding the pass-fail Identification and Vectoring Procedures lab test.

Aviation Electrician's Mate (AE)

Description of Variables. The Aviation Electrician's Mate (AE) school divides the curriculum and testing sequence into 15 units. The school assesses student progress using Knowledge, Performance, and Comprehensive tests. The tests have a valid range from 0-100. Table 7 presents the units and corresponding tests for the AE curriculum. The school sets the minimum passing score for each test at 63. Students who do not achieve the minimum passing score take one retest per test. For students passing the retest, the AE school assigns a score of 63 which counts toward the student's final school grade (FSG). For students who fail the retest, an Academic Review Board forms a recommendation as to the student's status. For the purposes of this study, RGI entered all initial test scores into the database.

For each student, the school computes a unit grade from the appropriate Knowledge, Performance, and Comprehensive test scores. The school then calculates the FSG as a weighted average of the unit grades. See Appendix C for test and unit weights. The Student Action Code variable represents the graduation status of the student. See Appendix B for descriptions of the various disenrollment categories.

Sample. The sample consisted of 231 students. We excluded from some analyses the 29 cases that did not take every test.

Results and Discussion. We computed descriptive statistics for each of the test variables. Table 8 lists the descriptive statistics for all variables.

Next, we conducted a factor analysis on the set of all test variables. The scree test and the factor loadings indicated two factors. Table 9 lists the communalities, factor loadings, and factor score coefficients for each of the

Table 7

AE School Instructional Units and Tests

Unit	Test No.	Description (Name - Type of Test[a])
0	301	Knowledge test covering Whole Numbers, Fractions, Decimals, and Basic Algebra (Math - K)
1	311	Knowledge test covering Basic DC Theory (DC Theory-K)
2	322	Performance test covering DC Series-Parallel Circuits (DC Circuits-P)
	321	Knowledge test covering Basic DC Circuits (DC Circuits-K)
3	332	Performance test covering Basic AC Theory (AC Theory-P)
	331	Knowledge test covering Basic AC Theory (AC Theory-K)
4	342	Performance test covering LC Parallel Resonant Circuits (LC Circuits-P)
	341	Comprehensive knowledge test covering all subject material on tests #301 through #342 (Comp. 1)
5	352	Performance test covering Diodes, Transistor Amplifiers, Integrated Circuits, and Cathode Ray Tubes (Diodes, etc.-P)
	351	Knowledge test covering Applications of Electronic Circuits (Elect Applic.-K)
6	361	Knowledge test covering Digital Fundamentals (Digital-K)
7	372	Performance test covering Maintenance Data Forms, an Intro to Troubleshooting, and Interior Light (Maint. etc.-P)
	371	Knowledge test covering Basic Troubleshooting (Troubleshooting-K)
8	382	Performance test covering AC and DC Power Distribution Systems (AC/DC Power-P)
	381	Knowledge test covering Generators (Generators-K)
9	392	Performance test covering Hydraulics Arresting Gear System (Hydr. Gear-P)
	393	Performance test covering Hydraulics Speed Brake System (Hydr. Brake-P)
	394	Performance test covering Hydraulics Flap System (Hydr. Flap-P)
	395	Performance test covering the Hydraulics Landing Gear System (Hydr. Landing-P)
	396	Performance test covering the Hydraulics Nosewheel Steering System (Hydr. Steering-P)
	391	Comprehensive knowledge test covering all subject material on tests #352 through #396 (Comp 2)
10	402	Performance test covering the Fuel Quantity System (Fuel System-P)
	403	Performance test covering the Simple Synchros System (Synchros-P)
	404	Performance test covering the Pitot Static System (Pitot Static-P)
	401	Knowledge test covering Indicating Systems (Indicating-K)
11	412	Performance test covering Attitude Headings and Reference Systems (Attitude Hdgs.-P)
	411	Knowledge test covering the Navigation System (Navigation-P)
12	422	Performance test covering the Inertial Navigation System (Inertial Nav.-P)
	421	Knowledge test covering the Inertial Navigation and Automatic Flight Control System (Inertial Nav.-K)
13	432	Performance test covering the Jet Ignition System (Jet Ignition-P)
	433	Performance test covering the Engine RPM Indicating System (Engine RPM-P)
	434	Performance test covering the Turbine Inlet Temperature System (Turbine Temp.-P)
	435	Performance test covering Anti-Ice and Deice Systems (Ice Systems-P)
	436	Performance test covering Anti-ice and Deice Systems (Ice Systems2-P)
	431	Knowledge test covering Engine Instruments (Eng Instr.-K)
14	442	Performance test covering the Angle of Attack System, the Fire Warning System, and Scheduled/Unscheduled Maintenance (Attack, etc.-P)
	441	Comprehensive test covering all subject material on tests #402 through #442 (Final Comp.)
15	451	Knowledge test covering Avionics Corrosion (Avionics-K)

[a]Type of test refers to either Knowledge (K) or Performance (P)

Table 8

Descriptive Statistics for AE Variables

Variable	n	Mean	Std Dev	Skew	Kurtosis	Minimum	Maximum
Math - K	228	84.890	11.624	-1.635	3.311	32.50	100.00
DC Theory - K	228	81.271	12.824	- .673	.314	30.30	100.00
DC Circuits - P	226	91.692	13.319	-2.135	3.929	50.00	100.00
DC Circuits - K	226	80.147	14.996	- .981	.585	26.90	100.00
AC Theory - P	222	98.712	4.043	-4.211	21.940	68.00	100.00
AC Theory - K	222	82.744	11.667	- .746	.239	38.70	100.00
LC Circuits - P	220	97.350	5.751	-3.693	21.840	50.00	100.00
Comp. 1	220	78.717	11.496	- .488	.068	41.50	100.00
Diodes. etc. - P	218	95.477	7.822	-2.975	11.607	50.00	100.00
Elect Applic. - K	218	77.045	12.232	- .563	.199	34.30	100.00
D[illegible]al - K	216	85.590	9.559	-1.198	2.689	37.50	100.00
Maint.. etc. - P	215	91.484	13.694	-2.157	.166	50.00	100.00
Troubleshtg - K	215	83.907	10.401	- .615	- .171	52.00	100.00
AC/DC Power - P	213	86.178	18.058	-1.296	.088	50.00	100.00
Generators - K	212	76.566	13.940	- .527	- .219	37.50	100.00
Hydr. Gear - P	208	89.958	12.202	-1.927	3.547	50.00	100.00
Hydr. Brake - P	208	86.159	16.595	-1.358	.509	50.00	100.00
Hydr. Flap - P	208	91.457	13.380	-2.267	.427	50.00	100.00
Hydr. Landing - P	208	91.697	12.693	-2.298	4.820	50.00	100.00
Hydr. Steering - P	208	89.212	15.098	-1.826	2.145	50.00	100.00
Comp. 2	206	76.650	11.204	- .126	- .614	44.00	100.00
Fuel System - P	206	90.601	15.518	-2.994	11.423	00.40	100.00
Synchros - P	206	92.199	10.284	-2.348	6.500	50.00	100.00
Pitot Static - P	206	91.749	7.312	- .569	- .698	70.00	100.00
Indicating - P	206	78.974	10.660	- .425	- .103	48.60	100.00
Attitude Hdgs. - P	206	85.949	17.833	-1.605	2.270	00.40	100.00
Navigation - P	206	74.598	11.280	- .027	- .462	47.20	100.00
Inertial Nav. - P	203	90.726	11.157	-3.682	22.832	00.40	100.00
Inertial Nav. - K	203	76.717	11.353	- .228	- .462	46.70	100.00
Jet Ignition - P	203	89.063	13.824	-2.748	10.015	00.40	100.00
Engine RPM - P	203	94.783	6.238	-2.638	10.058	50.00	100.00
Turbine Temp. - P	203	92.013	12.376	-4.496	27.489	00.40	100.00
Ice Systems - P	203	92.201	13.143	-4.288	24.166	00.40	100.00
Ice Systems2 - P	203	89.885	15.745	-2.288	4.895	9.60	100.00
Eng Instr. - K	203	82.067	10.762	- .623	- .131	46.70	100.00
Attack, etc. - P	203	88.557	10.828	-1.581	3.041	50.00	100.00
Final Comp.	203	75.123	10.572	- .513	.487	34.00	100.00
Avionics - K	203	85.564	11.062	-1.882	6.843	22.20	100.00

Table 9
Communalities, Factor Loadings and Factor Score Coefficients for AE Variables

Variable	Communality	Factor Loadings		Factor Score Coefficients	
		Factor 1: Knowledge	Factor 2: Performance	Factor 1: Knowledge	Factor 2: Performance
Math - K	.233	.425	.229	.044	.016
DC Theory - K	.424	.635	.142	.150	-.079
DC Circuits - P	.174	.319	.267	.022	.051
DC Circuits - K	.443	.603	.281	.105	.022
AC Theory - P	.003	.048	.024	-.001	-.003
AC Theory - K	.395	.543	.318	.065	.050
LC Circuits - P	.141	.372	.047	-.059	-.036
Comp. 1	.386	.589	.198	.111	-.029
Diodes, etc. - P	.022	.149	-.007	-.025	-.021
Elect Applic. - K	.377	.530	.311	-.067	.045
Digital - K	.413	.557	.321	.086	.045
Maint. etc - P	.162	.229	.332	-.004	.081
Troubleshooting - K	.349	.532	.258	.079	.027
AC/DC Power - P	.193	.236	.371	-.012	.094
Generators - K	.447	.578	.337	.080	.062
Hydr. Gear - P	.181	.111	.411	-.044	.133
Hydr. Brake - P	.238	.133	.469	-.062	.177
Hydr. Flap - P	.311	.004	.558	-.105	.263
Hydr. Landing - P	.179	.225	.359	-.014	.090
Hydr. Steering - P	.192	.020	.438	-.067	.162
Comp. 2	.416	.581	.281	.092	.010
Fuel System - P	.216	.141	.444	-.043	.145
Synchros - P	.091	.186	.238	-.002	.046
Pitot Static - P	.201	.159	.420	-.034	.131
Indicating - K	.334	.558	.151	.099	-.049
Attitude Hdgs. - P	.013	.100	.056	.003	.012
Navigation - P	.434	.586	.300	.094	.035
Inertial Nav. - P	.048	.053	.214	-.027	.061
Inertial Nav. - K	.390	.599	.178	.115	-.040
Jet Ignition - P	.127	.127	.333	-.032	.101
Engine RPM - P	.071	.259	.066	.031	-.015
Turbine Temp. - P	.036	.191	-.001	.023	-.022
Ice Systems - P	.012	.049	.099	-.022	.026
Ice Systems2 - P	.005	-.067	-.026	-.005	.005
Eng Instr. - K	.348	.583	.091	.113	-.081
Attack, etc. - P	.003	.002	.061	-.010	.021
Final Comp.	.361	.584	.142	.125	-.050
Avionics - K	.089	.297	.039	.047	-.031

Note. n = 202

variables. Based on the results of this factor analysis, we labeled the first factor Knowledge and the second factor Performance. The majority of the tests that load .30 or greater on Factor 1 are knowledge tests, and the majority of tests that load .30 or greater on Factor 2 are Performance tests. Notice that the tests that load above .30 on both factors load highest on the factor representing the testing format, either knowledge or performance. For example, knowledge Test 331 (AC Theory) loads .54 on Factor 1 and .32 on Factor 2.

In order to examine whether a knowledge test versus performance test distinction could explain aspects of school performance, we created both a Knowledge composite variable (by taking an average of the knowledge tests) and a Performance composite variable (by taking an average of the performance tests). We identified three phases of AE training by examining the content covered by the three comprehensive exams and created composite variables based on the three content areas. The Phase1 composite variable represents tests 301-341 which covered mathematics and basic electrical theory. The Phase2 composite variable represents tests 352-391 which covered more complex topics including electronic circuitry, generators and hydraulic systems. Finally, the Phase3 composite variable represents tests 402-451 which covered various aviation systems. Additional composites included the Sum1 and Sum2 variables. For Sum1 we took a simple average of all the knowledge tests that loaded .30 or above on Factor 1. Similiarly for Sum2, we took the average of all performance tests that loaded on Factor 2. Since the AE school computed the FSG using a 63 as the minimum score, we calculated our own final grade (FSG2) using initial test scores, and listed both as composite variables. We used the factor scores, Factor1 and Factor2, as additional composite variables. Table 10 lists the descriptive statistics for each of the composite variables listed above. The n varied for the composite

Table 10

Descriptive Statistics for AF Composite Variables

Composite	n	Rel[a]	Mean	Std Dev	Skew	Kurtosis	Min	Max
Sum1[c]	203	.901	82.133	6.782	-.043	-.546	65.58	97.82
Sum2[c]	202	.804	87.749	6.518	-.655	-.248	70.09	99.54
FSG	228	N/A	83.178	6.621	-.663	1.843	53.90	98.20
FSG2[d]	202	.900	83.740	5.736	.074	- .452	69.34	98.20
Know[e]	203	.895	81.107	6.981	.041	- .553	63.96	97.35
Perf[f]	202	.656	90.273	4.368	-.538	.032	76.55	99.70
Phase1[g]	220	.741	87.263	6.753	-.430	-.647	68.66	99.06
Phase2[h]	206	.788	80.384	6.301	-.475	-.325	61.88	92.64
Phase3[i]	202	.700	86.770	4.458	-.129	.033	74.31	98.21

[a]These are composites based on communality estimates and the procedures described in the text.
[b]Sum1: Average of all knowledge tests with Factor 1 loadings greater than or equal to .30
[c]Sum2: Average of all performance tests with Factor 2 loadings greater than or equal to .30
[d]FSG2: Weighted average of all INITIAL test scores (See Appendix C for Test Weight Scheme.)
[e]Know: Average of all knowledge tests
[f]Perf: Average of all performance tests
[g]Phase1: Average of Tests 301 - 341
[h]Phase2: Average of Tests 352 - 391
[i]Phase3: Average of Tests 402 - 451

variables depending on the number of tests missing for each case.

Finally, we computed Pearson correlation coefficients for the composite variables. Table 11 presents the intercorrelations between all composite variables. Notice that FSG and FSG2 correlated .99 showing no support for using initial test scores to compute FSG.

These results also show that FSG correlates very highly with the knowledge composites: Factor1 (.90), Sum1 (.97), and Knowledge (.97). FSG shows lower correlations with the performance composites: Factor2 (.54), Sum2 (.78), and Performance (.77).

The strongest correlation with Factor2 occurs for Sum2 (.91), followed closely by Performance (.86). Sum2 and Performance also correlate very highly (.90).

Phase1 correlates the strongest with Sum1 (.88) suggesting an emphasis on knowledge tests in that phase. Phase2 correlates most strongly with Sum2 (.95),

Table 11

Correlations Among AE Composites and Factors

Comp	Factor1	Factor2	Sum1[a]	Sum2[b]	FSG	FSG2[c]	Know[d]	Perf[e]	Phase1[f]	Phase2[g]	Phase3[h]
Factor1	--										
Factor2	.17	–									
Sum1	.95	.45	–								
Sum2	.51	.91	.72	–							
FSG	.90	.54	.97	.78	–						
FSG2	.91	.54	.98	.79	.99	–					
Know	.95	.42	.98	.57	.97	.97	–				
Perf	.48	.86	.68	.90	.77	.77	.64	–			
Phase1	.82	.41	.88	.62	.84	.84	.86	.60	–		
Phase2	.60	.81	.77	.95	.83	.83	.77	.84	.66	–	
Phase3	.67	.47	.72	.61	.78	.79	.72	.79	.53	.56	–

[a]Sum1: Average of all knowledge tests with Factor 1 loadings greater than or equal to .30
[b]Sum2: Average of all performance tests with Factor 2 loadings greater than or equal to .30
[c]FSG2: Weighted average of all INITIAL test scores
[d]Know: Average of all knowledge tests
[e]Perf: Average of all performance tests
[f]Phase1: Average of Tests 301 - 341
[g]Phase2: Average of Tests 352 - 391
[h]Phase3: Average of Tests 402 - 451

suggesting an emphasis on performance in that phase. Correlations with Phase3 suggests a more even emphasis of knowledge and performance.

Recommendations. In addition to FSG, use the average of all Sum2 computed as an average of the following performance test names (numbers): Maintenance (372), AC/DC Power (382), all hydraulics tests (392 - 396), Fuel Systems (402), Pitot Static (404), Navigation (411), and Jet Ignition (432).

Aviation Ordnanceman (AO)

Description of Variables. The AO school revised the first half of the curriculum in April 1991. We labeled the curriculum before this date "Curriculum A" and the curriculum after this date "Curriculum B". Table 12 lists the units covered by both Curriculum A and B. Unit 0 from curriculum B covers units 0 and 1 from Curriculum A. The school does not test students on unit 0 in either curriculum. Units 3 and 4 from Curriculum A do not exist as separate lessons in Curriculum B. However, units 2 and 1 from Curriculum B include the material covered in units 3 and 4 from Curriculum A, respectively. Hence, Curriculum B covers the same material as Curriculum A. However, only the last half of the curricula share the same lessons and tests.

Table 12

AO School Units of Instruction from Curricula A and B

Unit	Topic
	Curriculum A (prior to April 1991)
0	Enlisted Aviation Basic Training and Indoctrination
1	Introduction and Indoctrination
2	Electricity
3	Publications and Administration
4	Aircraft Maintenance
5	Ammunition and Magazines
6	Ammunition Ordnance
7	Aircraft Guns
8	Guided Missiles
	Curriculum B (April 1991 to April 1992)
0	Introduction and Indoctrination
1	Naval Aviation Maintenance
2	Electricity
5	Ammunition and Magazines
6	Ammunition Ordnance
7	Aircraft Guns
8	Guided Missiles

The school administered a third curriculum to classes 91210, 91240, and 91260 during May and June of 1991. These three classes piloted a revised second half of the curriculum that the school implemented April 24, 1992. The last examinees for this study completed the AO school in March 1991. Therefore, only classes 91210, 91240, and 91260 completed the third curriculum. We did not analyze this data from the third curriculum because we collected only two cases from these three classes, and because the school made several changes between the pilot curricula they completed and the curricula the school actually implemented on April 24, 1992.

For each unit of instruction, students receive practical work and a written knowledge test. Students also receive a within-course comprehensive test at the conclusion of Unit 2 and a final comprehensive knowledge test at the conclusion of training. In addition, Curriculum B students receive a within-course comprehensive performance test. The school requires a minimum passing score of 63% for all tests. Students who do not pass a knowledge progress test, the within-course comprehensive test or the final comprehensive knowledge test receive remedial instruction and a retest. The school assigns the minimum passing score to those passing a retest. Students who fail the retest must appear before the Academic Review Board (ARB). Students who fail practical work do not receive remediation or retesting, but they do continue on in the curriculum and they keep their failing score. There is no retesting for Curriculum B students who fail the within-course comprehensive performance test. Students who fail must appear before the ARB.

We entered only the initial test scores and not the school-assigned score (63%) for successful retests. The student action code variable

provides the graduation status of the student. See Appendix B for descriptions of the various disenrollment categories.

Table 13 lists the specific tests and practical work used in the AO school. The school measures all tests and practical work on a scale from 0 to 100. For each student, the school computes a Final School Grade (FSG) from a weighted average of the corresponding Knowledge tests and Practical work. See Appendix D for practical work and test weights.

Sample. The sample consisted of 290 students. The school administered Curriculum A to the 72 students who attended the AO school before April 1991. Of the 72 Curriculum A students, 24 had an incomplete data set, reducing the final sample available for analyses to 48. We conducted no analyses on these data because the sample was so small and because this was the older curriculum. Therefore, the final sample consisted of 213 cases from Curriculum B (5 cases contained missing data).

Results and Discussion. We computed descriptive statistics for each of the test variables. Table 14 lists the descriptive statistics for all variables.

Next, we conducted a factor analysis on the set of all test variables. The scree test and the factor loadings indicated two factors. Based on the results of the factor analysis, we labeled the first factor Knowledge and the second factor Practical. All tests that loaded .30 or greater on Factor 1 were Knowledge tests and all tests that loaded .30 or greater on Factor 2 were practical work with the exception of Maintenance - K and Pubs/Maint - K. Although Maintenance - K loaded over .30

Table 13

Descriptions of AO Variables

Unit	Test No.	Description (Name - Type of Test[a])
		Curriculum A only
1	111	**Practical Work:** Introduction and Indoctrination. Introduction to the AO Field. General Ordnance Safety. Tool Control. Introduction to Electricity. Theory of a Series Direct Current Circuit. Conductors. and Insulators. Application of current in a Direct Current Armament Circuit. Measuring current. Voltage, and Resistance with a Multimeter. Introduction to Voltage in a Series Armament Circuit. Introduction to Resistance in a Series Armament Circuit. Application of Ohm's Law. Relationship and Application of current. Voltage. and Resistance in a Series Armament Circuit. Measuring current. Voltage, and Resistance in a Series Direct Current Circuit with a Multimeter. (Intro Elect - P)
1	113	**Knowledge Test:** See Module #111 for description of test material. (Intro Elect - K)
1	121	**Practical Work:** Current. Voltage. and Resistance in a Parallel Armament Circuit and Measuring it with a Multimeter. Troubleshooting Parallel Armament Circuits. Current. Voltage, and Resistance in a Combination Armament Circuit. Troubleshooting and Measuring Combination Armament Circuits. Transformers. Application of Transformers in an Armament Circuit. Filters Relays. Maintenance. and Repair of Armament Circuits. Electrical Control Devices. Protection Devices and Symbols. 6E10 Training Device Familiarization. Aircraft Troubleshooting (6E11 Training Device). (Circuits - P)
1	123	**Knowledge Test:** See Module #121 for description of test material. (Circuits - K)
2	201	**Practical Work:** Wiring Code and Diagrams. Aircraft Armament Circuits. Suspension. and Releasing Equipment. Introduction to the A-4 Aircraft. Aircraft Maintenance Manuals. Aircraft Armament Test Equipment. Aircraft Preparation and Inspection. Introduction to Aircraft Armament Troubleshooting Techniques. Release and Control Checks. System Troubleshooting Techniques and Documentation. (Intro Aircraft - P)
2	203	**Knowledge Test:** See Module #201 for description of test material. (Intro Aircraft - K)
3-4	343	**Knowledge Test:** Introduction to NAVSEA Publications. Administrative Publications. Ordnance Safety and Supply Publications. Introduction to NAVAIR Publications. Loading Manuals and Checklists. Introduction to Aircraft Corrosion. Corrosion Control Manual. Theory of Corrosion. (Pubs/Corrosion - K)
		Curriculum B only
1	101	**Practical Work:** Naval Aviation Maintenance Program and Discrepancy Reporting Program. Planned Maintenance Systems. Maintenance Data Forms. Foreign Object Damage, Tool Control. Common Hand Tools. Aircraft Hardware, Torquing and Safetying, Shop Project. (Maintenance - P)
1	110	**Knowledge Test:** See Module #101 for description of test material. (Maintenance - K)
1	102	**Practical Work:** Corrosion Control Manuals, Corrosion Theory, Corrosion Control Program, Corrosion Corrective Maintenance, Corrosion Inspections, Paint and Touch-up, Preservation/ Depreservation. Emergency Corrosion Treatment, Aircraft Cleaning. (Corrosion - P)
1	120	**Knowledge Test:** See Module #102 for description of test material. (Corrosion - K)
2	221	**Practical Work:** Electrical Safety, Electrical Fundamentals, Ohm's Law, Measuring Electrical Values, Protective Control Devices. (Electrical - P)
2	210	**Knowledge Test:** See Module #221 for description of test material. (Electrical - K)

[a]Refers to Practical work (P) or Knowledge test (K)

Table 13 (Continued)

Unit	Var. No.	Description (Name - Type of Test[a])
2	222	**Practical Work:** Introduction to Publications. Wire Maintenance. Troubleshooting. Aircraft Armament Test Equipment. Loading Manual (Chapters 1-6) and NA-01-700. Aircraft Armament Systems. Introduction to the Weapons Systems Trainer. Weapons System Functional Checks and Troubleshooting. (Pubs/Maint - P)
2	220	**Knowledge Test:** See Module #222 for description of test material. (Pubs/Maint - K)
1-2	230	**Within-course Comprehensive Knowledge Test:** covers test material in Modules #101 through #220 (Comp 1- K)
1-2	231	**Within-course Comprehensive Performance Test:** covers test material in Modules #101 through #220 (Comp 2 - P)
		Curricula A and B
5	501	**Practical Work:** Ammunition Stowage Ashore. at advanced Bases. and Afloat. Identification and Types of Magazines Ashore. Magazine Temperatures and Safety Devices. Ammunition Handling and Transportation Equipment. Procedures for Ordering and Turning in Ammunition. (Ammunition - P)
5	503	**Knowledge Test:** See Module #501 for description of test material. (Ammunition - K)
6	611	**Practical Work:** Introduction to Airborne Ordnance. General Purpose Bombs. Introduction to Freefall and Retarded Airborne Weapons. Introduction to Aircraft Mechanical Bomb Fuses and Boosters. Introduction to Electrical Bomb Fuses. Practice Bombs and Signals. Laser Guided Bomb AGM-123 Skipper Missile. Cluster Bomb Unit (CBU). Firebombs and Associated Components. Special Purpose Munitions. Arming Wire. (Bombs - P)
6	613	**Knowledge Test:** See Module #611 for description of test material. (Bombs - K)
6	621	**Practical Work:** Introduction to Airborne Rockets. Rocket Components. Introduction to Pyrotechnics. Introduction to Ammunition Suspension Equipment. Aircraft Arming Signals. Conventional Weapons Loading/Unloading. Integrated Rapid Rearming System (IRRS). (Rockets - P)
6	623	**Knowledge Test:** See Module #621 for description of test material. (Rockets - K)
7	701	**Practical Work:** Introduction to 20MM Aircraft Guns. Aircraft Ammunition 20MM. Introduction to the M61A1 Vulcan Gun. Nomenclature and Function of the Major Components of the M61A1 Vulcan Gun. M61A1 Vulcan Gun linkless Ammunition Loading System. Introduction to the A-7E. F-14. F/A-18 Gun System. General Aircraft Safety. LALS Loading/Downloading. (Aircraft Guns - P)
7	703	**Knowledge Test:** See Module #701 for description of test material. (Aircraft Guns - K)
8	801	**Practical Work:** Introduction and Function of Air-Launched Guided Missiles. Introduction and Function of the Shrike Missile and its Components. Introduction and Function of the Sidewinder Missile and its Components. Introduction and Function of the Sparrow III Missile and its Components. Intro and Function of the Standard Arm Missile. Introduction and Function of the Phoenix Missile. Introduction and Function of the Walleye Weapon. Introduction to the New Missiles. Missile Handling Equipment. Missile Launching Equipment. Procedures and Missile Safety. Weapons Assembly. Inspection. Loading. Arming. Dearming. Downloading. and Disassembly. (Missiles - P)
8	803	**Knowledge Test:** See Module #801 for description of test material. (Missiles - K)
	900	**Final Comprehensive Test:** (Curriculum A) - Entire course comprehensive test. (Curriculum B) - Covers from Module #231 through #803. (Final Comp.)

[a]Refers to Practical work (P) or Knowledge test (K)

Table 14

Descriptive Statistics for AO Variables - Curriculum B

Variable	n	Mean	Std Dev	Skew	Kurtosis	Min	Max
Maintenance - P	218	92.241	9.042	-4.874	9.042	8.10	100.00
Maintenance - K	218	77.541	11.000	- .444	- .165	46.00	98.00
Corrosion - P	218	95.033	7.847	-5.548	39.907	26.90	100.00
Corrosion - K	217	85.862	9.537	- .382	- .394	56.00	100.00
Electrical - P	217	92.179	6.952	-2.362	10.519	44.50	100.00
Electrical - K	216	84.704	8.062	- .607	.134	60.00	100.00
Pubs/Maint - P	216	92.991	7.675	-3.474	19.200	35.50	100.00
Pubs/Maint - K	218	82.787	10.689	- .571	- .305	54.00	100.00
Comp. 1 - K	216	83.697	7.854	- .374	- .282	61.30	100.00
Comp. 1 - P	218	95.185	8.400	-7.088	74.034	1.00	100.00
Ammunition - P	216	93.076	9.790	-3.882	26.177	9.00	100.00
Ammunition - K	216	82.500	9.904	- .693	.212	50.00	100.00
Bombs - P	214	94.031	7.182	-2.774	11.522	51.40	100.00
Bombs - K	214	84.738	10.585	- .890	.429	48.00	100.00
Rockets - P	214	93.009	10.489	-4.688	32.144	00.70	100.00
Rockets - K	214	85.350	10.904	-1.015	1.429	40.00	100.00
Aircraft Guns - P	214	95.476	10.008	-4.968	32.460	9.10	100.00
Aircraft Guns - K	214	81.196	12.681	- .774	1.871	20.00	100.00
Missiles - P	214	94.582	7.872	-2.616	9.694	45.60	100.00
Missiles - K	214	82.766	11.723	- .421	- .489	48.00	100.00
Final Comp.	214	86.785	10.181	- .431	- .992	64.00	100.00

on both Factors, it loaded considerably higher on Factor 1. Table 15 lists the communalities, factor loadings, and factor score coefficients for each of the variables.

In order to examine whether a knowledge test versus performance test distinction could explain aspects of school performance, we created two composite variables: one based on the sum of the knowledge tests and the other based on the sum of the practical work. We identified two phases of the AO training based on the material and tests covered by the two comprehensive exams. The Phase1 composite variable consisted of an

Table 15

Communalities, Factor Loadings and Factor Score Coefficients for AO Variables - Curriculum B

Variable	Communality	Factor Loadings		Factor Score Coefficients	
		Factor 1: Knowledge	Factor 2: Practical	Factor 1: Knowledge	Factor 2: Practical
Maintenance - P	.191	.260	.351	.020	.074
Maintenance - K	.431	.571	.323	.127	.035
Corrosion - P	.227	.105	.465	.006	.051
Corrosion - K	.354	.544	.240	.112	.025
Electrical - P	.121	.197	.289	.006	.079
Electrical - K	.289	.514	.158	.074	-.001
Pubs/Maint - K	.247	.214	.449	.008	.090
Pubs/Maint - P	.346	.534	.247	.105	.008
Compl - K	.570	.710	.257	.280	-.086
Compl - P	.045	.117	.179	.011	.008
Ammunition - P	.148	.143	.357	-.011	.067
Ammunition - K	.296	.531	.119	.111	.008
Bombs - P	.767	.032	.875	-.291	.727
Bombs - K	.426	.641	.124	.180	-.040
Rockets - P	.304	.215	.508	.032	.040
Rockets - K	.353	.582	.122	.128	-.024
Aircraft Guns - P	.101	.054	.314	-.017	.072
Aircraft Guns - K	.387	.578	.230	.127	-.008
Missiles - P	.221	.291	.369	.036	.042
Missiles - K	.294	.496	.218	.081	.046
Final Comp.	.187	.417	.116	.071	-.024

Note. n = 213

average of all knowledge tests and practical work up to and including the first comprehensive exam. The Phase2 variable consisted of an average of all knowledge work and practical work up to and including the second comprehensive exam. Additional composites included the Sum1 and Sum2 variables which took a simple average of all the tests that loaded .30 or above on Factor 1 and Factor 2, respectively. Since the AO school computed the FSG using a 63 as the minimum score, we calculated our own final grade (FSG2) using the initial test scores, and listed both as

composite variables. We used the factor scores, Factor1 and Factor2, as additional composite variables. Table 16 lists the descriptive statistics for each of the composite variables listed above. The n varied for the composite variables depending on the number of students with an incomplete data set.

Next, we computed Pearson correlation coefficients for the composite variables. Table 17 presents the composite variable intercorrelations. Since FSG and FSG2 correlate .97, this offers no support for using initial test scores to compute FSG.

Knowledge correlates highest (.95) with Factor1, followed closely by Sum1 (.94) and FSG (.89). Similarly, Practical correlates highest (.86) with Factor2, followed closely by Sum2 (.82). These findings support using the logical combinations of tests to assess the dimensions reflected in the factor analyses.

Table 16

Descriptive Statistics for AO Composite Variables - Curriculum B

Composite	N	Rel[a]	Mean	Std Dev	Skew	Kurtosis	Min	Max
Sum1[b]	213	.856	83.106	6.718	.010	-.428	65.38	98.20
Sum2[c]	214	.755	93.980	4.499	-1.585	3.015	75.97	99.84
FSG	218	N/A	86.128	5.422	-.036	-.605	72.90	98.20
FSG2[d]	213	.846	85.445	5.720	-.045	-.419	69.79	98.50
Knowledge[e]	213	.856	83.442	6.532	-.017	-.396	65.25	98.36
Practical[f]	214	.724	93.918	4.082	-1.310	1.792	79.18	99.62
Phase1[g]	215	.778	88.210	4.847	-.486	.153	73.64	98.56
Phase2[h]	214	.795	88.559	5.492	-.496	.106	71.10	99.64

[a]These are composites based on communality estimates and the procedures described in the text.
[b]Sum1: Average of tests 110, 120, 210, 220, 230, 503, 613, 623, 703, 803
[c]Sum2: Average of tests 101, 102, 222, 501, 611, 621, 701, 801, 900
[d]FSG2: Final School Grade calculated using initial test scores
[e]Know: Average of all knowledge tests
[f]Prac: Average of all practical work
[g]Phase1: Average of tests 101 - 231
[h]Phase2: Average of tests 501 - 900

Table 17

Correlations Among AO Composites and Factors - Curriculum B

Comp	Factor1	Factor2	Sum1[a]	Sum2[b]	FSG	FSG2[c]	Know[d]	Prac[e]	Phase1[f]	Phase2[g]
Factor1	--									
Factor2	.08	--								
Sum1	.94	.34	--							
Sum2	.40	.82	.55	--						
FSG	.89	.42	.95	.66	--					
FSG2	.93	.39	.97	.62	.97	--				
Know	.95	.34	.99	.58	.96	.98	--			
Prac	.33	.86	.51	.93	.61	.58	.51	--		
Phase1	.76	.54	.85	.63	.80	.86	.83	.70	--	
Phase2	.76	.55	.85	.82	.92	.88	.87	.73	.67	--

[a]Sum1: Average of tests 110, 120, 210, 220, 230, 503, 613, 623, 703 and 803
[b]Sum2: Average of tests 101, 102, 222, 501, 611, 621, 701, 801, and 900
[c]FSG2: Final School Grade calculated using initial test scores
[d]Know: Average of all knowledge tests
[e]Prac: Average of all practical work
[f]Phase1: Average of tests 101 - 231
[g]Phase2: Average of tests 501 - 900

In reviewing the results with phase variables, we find that both Phase1 and Phase2 correlate more highly with knowledge composites than with performance composites. However, those more moderate correlations (.54 to .87) are not as supportive of a unidimensional relationship as are the results for the Knowledge and Practical Composites.

Finally, FSG correlates .61 with Practical and .96 with Knowledge. These findings support using FSG as an indicator of performance on knowledge tests but suggest using a separate indicator for performance on practical work.

Recommendation. In addition to FSG, use an average of all Practical tests.

Aviation Structural Mechanic (Structures) (AMS)

Description of Variables. The AMS school divides the curriculum and testing plan into 6 units. The school evaluates students on Knowledge, Performance, and Practical Work Test Scores, all of which can range from 0-100. The school sets 63 as the minimum passing score for each test. Students who do not achieve the minimum passing score take one retest per test. For students passing the retest, the AMS school assigns a score of 63. For students who fail the retest, an Academic Review Board assigns night study and allows the student to continue taking retests until they achieve the minimum passing score. RGI entered only the initial test scores into the database. We also entered the number of retests on each test. Student Action Code reflects graduation status or disenrollment category (See Appendix B). Table 18 describes the units and corresponding tests.

For each student, the school computes unit grades as weighted averages of the appropriate Knowledge, Performance, Practical Work, and Comprehensive test scores. The school then computes a Final School Grade (FSG) as a weighted average of the unit grades. The school computes the Unit Grades as shown in Table 19.

Sample. The sample consisted of a total of 307 students.

Results and Discussion. Table 20 displays descriptive statistics for the AMS variables. Factor analysis indicated two clear factors, one defined by the knowledge tests ("Knowledge"), the other defined by the performance tests and practical work ("Performance"). The performance test covering Maintenance and Material Documentation showed the only exception to this pattern. Table 21 displays the communalities, factor loadings, and factor score coefficients for the AMS variables, grouped by knowledge and performance test/practical work.

Table 18
AMS School Instructional Units and Variables

Unit	Variable	Description (Name - Type of Test[a])
1	101	Knowledge test covering a Basic Introduction to the AMS school (Basic Intro - K)
	103	Practical work covering the Introduction (Basic Intro - PW)
2	201	Knowledge test covering Maintenance and Material Documentation (Documentation - K)
	202	Performance test covering Maintenance and Material Documentation (Documentation - P)
3		**Section 1**
	311	Knowledge test covering Corrosion Control (Corrosion Control - K)
	313	Practical work covering Corrosion Control (Corrosion Control - PW)
		Section 2
	321	Knowledge test covering Aircraft Painting and all related areas (Aircraft Painting - K)
	322	Performance test covering Corrosion Control and Painting (Corrosion Control & Painting - P)
	323	Practical work covering Aircraft Painting (Aircraft Painting - PW)
4		**Section 1**
	411	Knowledge test covering Basic Aircraft Construction, Aircraft Structural Materials, the Fundamentals of Drawing Interpretation, the Bend allowance for 90 degree Bends, the Development of a Flat Layout, Flat Layout on Metal, Cutting Aircraft Structural Metal, Drilling Structural Metals, and how to Cut Structural Metals (Basic Aircraft Construction - K)
	413	Practical work covering topics in knowledge test #411 (Basic Aircraft Construction - PW)
		Section 2
	421	Knowledge test covering Forming Aircraft Structural Metals, the Installation of Permanent Fasteners, the Layout of Riveted Joints, Removal of Rivets and Scrap Metal, Layout and Drill Rivet Joints, and Countersinking (Forming Aircraft - K)
	422	Performance test covering topics in knowledge tests #411 and #421 (Basic Aircraft Construction & Forming - P)
	423	Practical work covering topics in knowledge test #421 (Forming Aircraft - PW)
		Section 3
	431	Knowledge test covering Repair of External Skin, Repair External Skin by Patching, Installation of Semipermanent Fasteners, the Installation of Turnlock Fasteners, and Making an Access Panel (Repair External Skin -K)
	433	Practical work covering topics in knowledge test #431 (Repair External Skin - PW)
		Section 4
	441	Knowledge test covering the Repair of Internal Structures, the Repair of a Damaged Rib, the Repair of a Damaged "U" Channel, and Nondestructive Metal Inspections (Repair Internal Structures - K)
	442	Performance test covering topics in knowledge tests #431 and #441 (Repair External and Internal - P)
	443	Practical work covering topics in knowledge test #441 (Repair Internal Structures - PW)
5		**Section 1**
	511	Knowledge test covering the Fabrication of Reinforced Plastics, the Repair of Reinforced Plastic, Transparent Plastic, and the Repair of Sandwich Construction (Reinforced Plastics - K)
	513	Practical work covering Aircraft Non-Metallics (Aircraft Non-Metallics - PW)
		Section 2
	521	Knowledge test covering the Fabrication of a Circular Patch, an Introduction to Composite Materials, and a Composite Material Repair Lab (Circular Patch - K)
6		**Section 1**
	611	Knowledge test covering Aircraft Flight Controls and Mechanisms, Planned Maintenance System, Aircraft Servicing, Fuel Cell Repair, Lubrication of an Aircraft, and the Service of a Pneumatic System (Flight Controls - K)
	613	Practical work covering topics in knowledge test #611 (Flight Controls - PW)
		Section 2
	621	Knowledge test covering Aircraft Jacking, the Maintenance of Wheels and Tires, Raise and Lower Complete Aircraft, Remove and Replace Wheel Assembly, the Maintenance of Arresting Hooks, Remove and Replace a Hook Point, and Flight Deck/Line Safety (Aircraft Jacking - K)
	623	Practical work covering topics in knowledge test #621 (Aircraft Jacking - PW)
	700	Final Comprehensive test given at the end of Unit 6 (Comprehensive - C)

[a]Key to Type of Test: K - knowledge, P - performance, PW - practical work, C - comprehensive

Table 19
AMS School Unit Grades and Test Weights

Unit	Weighted Test Components
Unit 1:	.60 x (#101) + .40 x (#103)
Unit 2:	.40 x (#201) + .60 x (#202)
Unit 3 Sec. 1:	.70 x (#311) + .30 x (#313)
Unit 3 Sec. 2:	.25 x (#321) + .50 x (#322) + .25 x (#323)
Unit 4 Sec. 1:	.60 x (#411) + .40 x (#413)
Unit 4 Sec. 2:	.30 x (#421) + .50 x (#422) + .20 x (#423)
Unit 4 Sec. 3:	.40 x (#431) + .60 x (#433)
Unit 4 Sec. 4:	.20 x (#441) + .50 x (#442) + .30 x (#443)
Unit 5:	.30 x (#511) + .30 x (#513) + .40 x (#521)
Unit 6 Sec. 1:	.60 x (#611) + .40 x (#613)
Unit 6 Sec. 2:	.60 x (#621) + .40 x (#623).

Note. The school computes FSG from the Unit Grades as:
FSG = .03 x (Unit 1) + .07 x (Unit 2) + .07 x (Unit 3 Sec. 1) + .10 x (Unit 3 Sec. 2) + .15 x (Unit 4 Sec. 1) + .15 x (Unit 4 Sec. 2) + .075 x (Unit 4 Sec. 3) + .075 x (Unit 4 Sec. 4) + .07 x (Unit 5) + .07 x (Unit 6 Sec. 1) + .07 x (Unit 6 Sec. 2) + .07 x (#700).

Table 20
Descriptive Statistics for AMS Variables

Variable	n	Mean	Std Dev	Skew	Kurtosis	Minimum	Maximum
Basic Intro - K	307	85.114	9.263	-1.585	6.501	27.50	100.00
Basic Intro - PW	307	94.199	4.460	-1.786	5.247	70.00	100.00
Documentation - K	307	77.323	11.615	-.806	.722	29.10	100.00
Documentation - P	307	88.651	11.551	-1.037	.202	48.00	100.00
Corrosion Control - K	305	85.929	7.819	-.619	.071	59.10	100.00
Corrosion Control - PW	305	92.898	4.606	-1.097	2.069	72.00	100.00
Aircraft Painting - K	305	83.975	8.782	-.676	.161	55.70	100.00
Corrosion Control & Painting - P	305	89.003	6.974	-1.257	2.984	53.00	100.00
Aircraft Painting - PW	305	88.480	7.308	-1.485	4.021	48.00	100.00
Basic Aircraft Construction - K	305	81.545	9.661	- .500	.008	49.20	100.00
Basic Aircraft Construction - PW	305	89.306	7.026	-1.957	7.301	42.10	100.00
Forming Aircraft - K	305	77.193	11.071	- .398	- .167	38.80	100.00
Basic Aircraft Construction & Forming - P	303	83.578	10.205	-1.750	10.049	6.00	100.00
Forming Aircraft - PW	303	73.833	8.707	.251	- 1.148	60.30	100.00
Repair External Skin - K	303	82.483	9.110	- .462	- .181	56.40	100.00
Repair External Skin - PW	302	76.092	6.610	- .099	- .490	56.00	100.00
Repair Internal Structures - K	302	86.072	12.478	-1.322	2.934	24.20	100.00
Repair External and Internal - P	302	79.801	9.719	- .428	- .199	46.00	100.00
Repair Internal Structures - PW	302	80.058	6.591	-.195	-.266	63.00	96.00
Reinforced Plastics - K	301	84.066	8.532	- .643	.623	51.20	100.00
Aircraft Non-Metallics - PW	301	85.642	7.459	- .489	.322	63.00	100.00
Circular Patch - K	301	82.546	9.058	- .489	.060	53.10	100.00
Flight Controls - K	301	80.452	9.497	- .302	- .292	53.20	100.00
Flight Controls - PW	300	83.517	7.316	.188	.365	63.00	100.00
Aircraft Jacking - K	300	90.484	7.300	-2.791	16.879	36.90	100.00
Aircraft Jacking - PW	300	84.838	7.684	-.102	.299	63.00	100.00
Comprehensive - C	300	75.675	7.667	- .159	.474	44.60	100.00

Table 21
Communalities, Factor Loadings, and Factor Score Coefficients for AMS Variables

Variable	Communality	Factor Loadings		Factor Score Coefficients	
		Factor 1: Knowledge	Factor 2: Perf/Prac	Factor 1: Knowledge	Factor 2: Perf/Prac
Basic Intro - K	.372	.596	.089	.107	-.008
Documentation - K	.308	.549	.077	.101	-.041
Corrosion Control - K	.359	.593	.085	.113	-.040
Aircraft Painting - K	.458	.634	.235	.123	.042
Basic Aircraft Construction - K	.383	.592	.180	.101	.010
Forming Aircraft - K	.435	.629	.199	.121	.017
Repair External Skin - K	.236	.478	.087	.070	-.008
Repair Internal Structures - K	.218	.458	.089	.064	-.013
Reinforced Plastics - K	.424	.636	.141	.127	-.013
Circular Patch - K	.261	.502	.093	.085	-.025
Flight Controls - K	.460	.653	.183	.143	.002
Aircraft Jacking - K	.214	.429	.173	.041	.028
Comprehensive - C	.580	.756	.089	.224	-.096
Basic Intro - PW	.130	-.042	.358	-.036	.136
Documentation - P	.154	.392	.031	.051	-.023
Corrosion Control - PW	.055	.210	.105	.026	.021
Corrosion Control & Painting - P	.155	.207	.334	-.001	.100
Aircraft Painting - PW	.081	.013	.284	-.012	.085
Basic Aircraft Construction - PW	.093	.087	.293	-.008	.084
Basic Aircraft Const. & Forming - P	.157	.182	.352	-.015	.109
Forming Aircraft - PW	.329	.175	.546	-.039	.228
Repair External Skin - PW	.296	.175	.515	-.026	.206
Repair External and Internal - P	.250	.021	.500	-.047	.195
Repair Internal Structures - PW	.171	.117	.397	-.025	.128
Aircraft Non-Metallics - PW	.270	.162	.494	-.035	.202
Flight Controls - PW	.088	.102	.278	-.005	.075
Aircraft Jacking - PW	.095	.066	.302	-.016	.092

Note. N = 300.

To better represent the factors using empirical composites, we developed the following measures. Sum1 refers to the mean of the variables with Factor 1 loadings greater than or equal to .30. Sum2 refers to the mean of the variables with Factor 2 loadings greater than or equal to .30. FSG indicated the school's Final School Grade, while FSG2 refers to the Final School Grade calculated using the initial test scores. Finally, we defined Knowledge as the mean of all knowledge tests, and Performance as the mean of all performance tests and practical work.

Table 22 shows descriptive statistics on these composite variables. Next, we computed Pearson correlation coefficients for the composite variables. Table 23 shows correlations among the composites and the factor scores. Since FSG and FSG2 correlate .99, this offers no support for using initial test scores to compute FSG. Knowledge and Sum1 correlate .98 with Factor1, followed by FSG (.84). Similarly, Performance correlates .97 with Factor 2 followed by Sum2 (.96). Finally, FSG correlates .69 with Performance and .90 with Knowledge. These findings support using FSG as an indicator of performance on knowledge tests but suggest using a separate indicator for performance on practical work.

Recommendations. In addition to Final School Grade, use Performance (the average of the performance tests and practical work).

Table 22
Descriptive Statistics for AMS Composite Variables

Composite	Rel[a]	Mean	Std Dev	Skew	Kurtosis	Min	Max
Sum1[b]	.88	83.038	5.825	.099	-.555	68.28	96.64
Sum2[c]	.68	83.064	4.020	-.093	-.347	70.83	92.50
FSG	N/A	83.383	4.300	-.090	.637	64.40	94.60
FSG2[d]	.86	83.273	4.197	.186	-.299	72.04	94.27
Know[e]	.88	83.038	5.825	.099	-.555	68.28	96.64
Perf[f]	.70	84.092	3.607	-.166	-.211	73.71	92.88

Note. N = 300.
[a]These are composites based on communality estimates and the procedures described in the text.
[b]Sum1: Average of Tests with Factor 1 loadings greater than or equal to .30
[c]Sum2: Average of Tests with Factor 2 loadings greater than or equal to .30
[d]FSG2: Weighted average of all initial test scores (See Table 19 for test weights)
[e]Know: (Sum of Tests 101, 201, 311, 321, 411, 421, 431, 441, 511, 521, 611, 621, 700)/13
[f]Perf: (Sum of Tests 103, 322, 413, 323, 422, 423, 433, 442, 443, 513, 613, 623, 202, 313)/14

Table 23
Correlations Among AMS Composites and Factors

Composite[a]	Factor1	Factor2	Sum1	Sum2	FSG	FSG2	Know
Factor 2	.11						
Sum1[b]	.98	.25					
Sum2[c]	.25	.96	.38				
FSG	.84	.58	.90	.69			
FSG2[d]	.85	.57	.90	.68	.99		
Know[e]	.98	.25	1.00	.38	.90	.91	
Perf[f]	.24	.97	.37	.97	.69	.69	.37

Note. N = 300.
[a]These are composites based on communality estimates and the procedures described in the text.
[b]Sum1: Average of Tests with Factor 1 loadings greater than or equal to .30
[c]Sum2: Average of Tests with Factor 2 loadings greater than or equal to .30
[d]FSG2: Weighted average of all initial test scores (See Table 19 for test weights)
[e]Know: (Sum of Tests 101, 201, 311, 321, 411, 421, 431, 441, 511, 521, 611, 621, 700)/13
[f]Perf: (Sum of Tests 103, 322, 413, 323, 422, 423, 433, 442, 443, 513, 613, 623, 202, 313)/14

Avionics Technician (AV)

The AV school administers knowledge and performance tests, and labs. In December, 1991, the AV school renumbered and made extensive changes to several of the course labs and tests. At that time, the instructors changed the AV school course number from 61 to 60. In the following sections, we present the variable descriptions and results for Course 61 only, because no cases were available for Course 60.

Description of Variables. The school measures all tests on a 0-100 scale and requires a minimum passing score of 70 for the course tests (knowledge, performance, and comprehensive). Students who fail a test appear before the Academic Review Board (ARB). The school then decides upon the student's status. ARB often permits such students to retest. The instructor assigns the minimum passing score (70) to students who pass the retest, and the school uses that minimum score in calculating the final school grade (FSG). The school sends students who fail the retest back to ARB for a second review. RGI entered only the initial test scores for each examinee, because the school assigns a score of 70 for all successful retests. The student action code variable provides the graduation status of the student. The school assigned an action code to those students who did not complete the course. See Appendix B for descriptions of the various disenrollment categories.

Within Course 61, the AV school altered, added, or deleted tests from its curriculum. The following describes the nature of each change and its date of occurrence.

In February of 1991, the AV school proposed major content changes for all Part 4 knowledge and comprehensive tests. From February to August of 1991, the school piloted the revised tests in classes 90820, 90821, 91010, 91011, 91140, 91141, 91280, and 91281. The new curriculum applies to all students registered in the course as of April 15, 1991 (Julian date 91105) in addition to the pilot classes listed above.

In addition to changing the content of the existing Unit 4 tests, the school introduced Knowledge Test 445 into the program. Only students in the pilot classes noted previously and students registered in the course as of 91105 received Knowledge Test 445.

On June 27, 1991 (Julian date 91178), the school changed the scoring method of the course labs from a percentage score to a satisfactory/unsatisfactory grade. The school kept the minimum passing score for each lab at 70%. For students who failed a lab, the school retained its policy of retesting them until they passed the lab.

Until June 28, 1991 (Julian date 91178), the school included scores from labs as well as knowledge, performance, and comprehensive tests to determine the final school grade (FSG) for Course #61. However, as of this date, the labs did not contribute towards the FSG. (See Appendix E for computation of the FSG.)

Table 24 presents the variable numbers and a description of the variables used in the AV school Course 61 data analysis. In parentheses, following each description, is the name assigned to each variable.

Table 24

Descriptions of AV School Variables - Course Number 61

Test No.	Description (Name-Type of Test)[a]
111	**Knowledge Test**: General Math: Fractions, basic algebra, equations, signed numbers, linear, trig., vector algebra, atomic structure (General Math-K)
109	**Lab**: Intro to DC circuit analysis & series DC circuit (Intro/DC Circuit-L)
121	**Knowledge Test**: DC Theory: multimeters, DC circuit analysis, electrostatics, batteries (DC Circuits-K)
119	**Lab**: Parallel circuits (Parallel Circuits-L)
122	**Knowledge Test**: DC theory: Series circuit analysis, parallel circuits (Series/Parallel Circuits-K)
129	**Lab**: Series parallel circuits, DC troubleshooting (T/S) (Series/Parallel DC T/S-L)
139	**Lab**: Voltage dividers (Voltage Dividers-L)
124	**Performance Test**: T/S DC circuits (T/S DC Circuits-P)
123	**Comprehensive Test**: DC Theory (Comprehensive1)
149	**Lab**: Application of test equipment (Test Equipment-L)
159	**Lab**: Resistive capacitive (RC) circuit analysis (R/C Circuit Analysis-L)
131	**Knowledge Test**: AC concepts, sine wave analysis, capacitators & capacitance, digital multimeters, RC circuit analysis, oscilloscopes (OSC) (AC Concepts/RC Circuit/OSC-K)
169	**Lab**: Resistive inductive (RL) circuit analysis & transformers (R/L Circuits,Transf.-L)
132	**Knowledge Test**: Inductors & inductance, RL circuit analysis, transformers (Inductance-K)
179	**Lab**: Series & parallel resonant circuits (Series/Parallel Circuits-L)
133	**Performance Test**: AC: Application of test equipment, transformers, RL & RC circuit analysis, series reactive circuits, RC & RL signal filters (RC/RL Circ.,Filt.-P)
100	**Comprehensive Test**: AC Theory: Content from lab #149 to test #133 plus inductive/capacitive/resistive analysis (Comprehensive2)
219	**Lab**: Amplifier biasing, transistor amps (Amplifiers-L)
211	**Knowledge Test**: Semiconductor Devices: Positive/negative junctions, amps/transistor theory, amp biasing, elecrostatic discharge (Semiconductors-K)
229	**Lab**: Limiters and clampers (Limiters & Clampers-L)
221	**Knowledge Test**: Solid State Devices/Electric Circuits: Amp gain & decibels feedback amps, limiters & clampers, classification & coupling, OSCs (Solid State-K)

[a] Key to type of test: K - Knowledge
L - Lab
P - Performance

Table 24 (Continued)

Test No.	Description (Name-Type of Test)[a]
239	**Lab**: OSCs & voltage regulators (OSCs & Voltage Regulators-L)
241	**Knowledge Test**: Power Supplies/Naval Aviation Maint. Program: OSCs, voltage regulators, rectifiers & filters, audio amps, power supply, maint. data systems (Pwr. Supplies/Naval Av. Maint.-K)
249	**Lab**: Sig. tracing AM receivers (AM Receivers-L)
251	**Knowledge Test**: AM Communication Theory: Radio-frequency (RF) comm., block diag/tracing/sig analysis/injecting AM Revr. transmitter (Xmtr) & RX fundamentals, sig tracing a superheterodyne RX (AM Communication Theory-K)
259	**Lab**: AM TX, RF amp & 1st RX mixer (AM Xmtr, RF Amp. & 1st Revr Mixer-L)
269	**Lab**: 1st intermediate freq. (IF) amp & 2nd RX mixer, detector & preamp, audio output amp (1st IF Amp. & 2nd Revr Mixer-L)
279	**Lab**: T/S: RX (T/S: Revr-L)
253	**Performance Test**: T/S: RX (T/S: Revr-P)
252	**Knowledge Test**: AM TX: RF & IF amps, 1st & 2nd RX mixer, detector-preamp, audio output amp (AM Xmtr-K)
289	**Lab**: Low & high freq. OSC, 1st & 2nd transmitter mixer & OSC, freq. amp, doubler (OSC, Xmtr-L)
299	**Lab**: Modulator (MOD) & RF power amp, beat freq. OSC, RX power supply & voltage regulator (Power, Volt reg.-L)
254	**Knowledge Test**: High & low freq. OSC, 1st TX mixer, freq. doubler/amp, beat freq. OSC, MOD & RF power amp, TX power supply & voltage regulator (OSC, Power-K)
209	**Lab**: Troubleshooting: AM & FM TX (Trouble/S-L)
255	**Performance Test**: AM TX (AM Xmtr-P)
200	**Comprehensive Test**: Material from Lab 219 to Test 255 plus FM theory/MOD/detection/auto freq. control, transmission lines, antenna (ant), T/S FM TX, radio wave propagation (Comprehensive 3)
309	**Lab**: Integrators & differentiators (Integrators & Differentrs-L)
319	**Lab**: Blocking OSCs & multivibrators (Blocking OSCs & Multivibrators-L)
321	**Knowledge Test**: Electromechanical/solid state devices, synchros, servosystems, resolvers/accelerometers, blocking OSCs, gyros, integrators & diffrnttrs, motors, multivibrators (Elec. Mech/Solid State-K)
329	**Lab**: Sweep generators (Sweep Generators-L)
339	**Lab**: Switching power supplies (Switching Power Supplies-L)
331	**Knowledge Test**: Power Supplies: Sweep generator, step & level counters, diffrntl/oprtnl amps, voltage multipliers, multiphase/switching power supplies, integrated circuits (Power Supplies-K)

[a]Key to type of test: K - Knowledge
L - Lab
P - Performance

Table 24 (Continued)

Test No.	Description (Name-Type of Test)[a]
349	**Lab**: Logic gates (Logic Gates-L)
341	**Knowledge Test**: Number systems, logic gates, flip-flops (Logic Gates-K)

In February of 1991, the school proposed major content changes for all knowledge and comprehensive tests of Part 4. From February to August of 1991, the school piloted the revised tests in 8 classes: #90820, #90821, #91010, #91011, #91140, #91141, #91280, and #91281. As of August, 1991, the school adopted the new curriculum for all students. Therefore, the new curriculum applies to all students registered in the course as of April 15, 1991 (Julian: 91105) in addition to the pilot classes listed above.

431	**Knowledge Test** **(Only if Registered Before 91105 and NOT in Pilot Class)** Maintenance instruction manual, interconnection wiring diagrams & installation/ inspections, instalation/ inspection of avionic systems, line replaceable units, radar fundamentals, block diagram of an ASR system, ASR synchronizer display system, MOD/RX/TX system operation check, isolating malfunctioning units in ASR system, ant stabilization system, signal trace/block diagram analysis of sync./indicator/MOD/RX/ TX/ant stabilization system, T/S the ASR (Maint. Instruction Manual-K) **(Only if Registered After 91104 or in Pilot Class)** Radar fundamentals, maintenance instruction manual, ASR, signal tracing & block diagram analysis synch./ indicator, inspections & physical security (Maint. Instruction Manual-K)
441	**Knowledge Test** **(Only if Registered Before 91105 and NOT in Pilot Class)** Power supply 1/common devices/ Azimuth & tilt circuit analysis, closed loop servosystems, tubes, unit junction transistor OSC/bootstrap sawtooth gen., display indicator, monostable multivibrator/ down-counters/colpitts OSC, bleeder circuits, isolating parts of sync. display indicators (Pwr. Supply/Blk. Diag. Anlys-K) **(Only if Registered After 91104 or in Pilot Class)** Block diag analysis ant/ transmitter, signal tracing ant, T/S the ASR (Pwr. Supply/Blk. Diag. Anlys-K)
442	**Knowledge Test** **(Only if Registered Before 91105 and NOT in Pilot Class)** 3-Phase power supply/over-load protection circuit, control circuits, resonant cavities, pulse forming network/silicone control rectifier, magnetrons, isolating parts in the MOD/TX sect., waveguide issues: Principles, duplexer filters, coaxial coupling, attenuators, microwave radiating, switching & receiving devices, termination (3-Phase Pwr. Supply/Circ. Anlys.-K) **(Only if Registered After 91104 or in Pilot Class)** Circuit analysis sync., vacuum tubes & circuit deflection system, resonant cavities, intermediate bench setup, magnetrons (3-Phase Pwr. Supply/Circ. Anlys.-K)
459	**Lab**: T/S: Ant, TX, & RX (T/S Ant, Xmtr & Revr-L)
443	**Knowledge Test** **(Only if Registered before 91105 and NOT in Pilot Class)** Short-slot hybrid mixer/ crystal current meter network, klystrons, auto/ intermed freq. amp control network, T/S the video detector/preamp (Short-slot Hybrid Mixer-K) **(Only if Registered After 91104 or in Pilot Class)** Circuit analysis transmitter, waveguide principles, reflex klystrons (Short-slot Hybrid Mixer-K)

In addition to changing the content of existing tests, the school introduced a new knowledge test (#445) into the program. Only students in the pilot classes noted previously and students registered in the course as of 91105 received Knowledge Test #445.

445	**Knowledge Test**: **(Only if registered after 91104 or in Pilot Class)** Circuit analysis RX, circuit analys/microwave ant, T/S: RX ant, alternate devices (Circ. Anlys., Revr Circuit-K)
444	**Performance Test**: T/S: special circuits (part 3 & 4 lab material) (T/S Spec. Circuits-P)

[a]Key to type of test: K - Knowledge
L - Lab
P - Performance

Table 24 (Continued)

Test No.	Description (Name-Type of Test)[a]
400	**Comprehensive Test:** **(Only if Registered Before 91105 and NOT in Pilot Class)** Covers material from pre- 91105 tests 431, 441, 442, & 443 (Comprehensive 4) **(Only if Registered After 91104 or in Pilot Class)** Covers material from post- 91104 tests 431, 441, 442, 443, & 445. (Comprehensive 4)
509	**Lab:** Clocks/counters, adders/ subtractors, registers (Clocks/Counters, Adders-L)
519	**Lab:** Multipliers (Multipliers-L)
512	**Performance Test:** Digital circuits (Digital Circuits-P)
511	**Knowledge Test:** Registers, multipliers/ dividers, clocks/counters, adders/subtractors (Registers/Multipliers/Dividers-K)
529	**Lab:** Signals (control/address, timing/data, memory), encoders & decoders (Signals, Encoders, & Decoders-L)
522	**Performance Test:** Content from lab #509 to lab #529 (Multipliers - Subtractors/Signals-P)
539	**Lab:** Intro to computer coding (Computer Coding-L)

As of July 2, 1990 (Julian date 90183), the school deleted Comprehensive Test 500 and administered Knowledge Test 521 at the end of Part 5. The school also revised Knowledge Test 521 to include material covered the last week of Part 5. Students entering the course before this date took Knowledge Test 521 during the 24th week of class, then they took Comprehensive Test 500 one week later. Students enrolling after this date did not take Comprehensive Test 500 (Comprehensive Test 500 deleted from analysis-only 5 cases). Instead, they took the revised Knowledge Test 521 in its place, during the 25th week.

521	**Knowledge Test:** **(Only if Registered Before 90183)** Computer basics, memory devices, microprocessors, timing signal anlys, data control, adders/memory, in-out interface/devices, encoders/decoders (Comp. Basics/Electrostatic Dish.-K) **(Only if Registerd After 90182)** covers material noted in test 521 above, plus electrostatic discharge & programming (Comp. Basics/Electrostatic Dish.-K)
500	**Comprehensive Test: (Only if Registered Before 90183)** Covers Part 5 material: Computer Fundamentals: Computer theory, processing circuits, programming (Comprehensive 5)
601	**Knowledge Test:** Corrosion, preventive maint., avionics equip. repair/treatment, equip. cleaning, measures for elect. bonding/grounding, emergency procedures (Corrosion, Prev. Maint.-K)
609	**Lab:** Soldering (Soldering-L)
619	**Lab:** Wire & connector repair, coaxial repair (Wire Repair-L)
611	**Performance Test:** Soldering, wire connector/ coaxial repair (Wire Repair-P)
600	**Knowledge Test:** Infrared/laser principles, fiber optics, cyrogenics, automatic test equipment, theater of nuclear warfare (Infrared/Laser Principles-K)
700	**Knowledge Test:** Basic integrated weapons, communication/navigation/ fire control/tactical radar subsyst., electronic counter measures, anti-sub warfare, electromagnetic interference awareness (Basic Integrated Weapons-K)

[a]Key to type of test: K - Knowledge
L - Lab
P - Performance

Sample. The initial sample consisted of 453 students who began training between March 1990 and November 1991. Because the AV school introduced a new version of Part 4 and beginning June 28, 1991 eliminated labs from the Final School Grade (FSG) computation, we divided the school within Course 61 into 3 groups. Group 1 included those students who received the old version of Part 4 (n=225). Group 2a included those students who received the new version of Part 4 and whose FSG included labs (n=88). Group 2b included students who received the new version of Part 4 and whose FSG did not include labs (n=83). Sample sizes for each group include only those students with complete data.

We excluded comprehensive test 500 from the analyses for all three groups because there were only 5 cases for that variable. We also excluded all labs from the factor analyses. Many of the labs had no variance, and an initial factor analysis procedure could not extract any factors using the remaining labs.

Results and Discussion. We conducted an analysis to determine if there were differences in Group 1 and 2 (2a and 2b combined) due to the introduction of a new version of Part 4. We conducted a multivariate analysis of variance (MANOVA) to test the covariance matrices of the test scores. A test for homogeneity of covariance matrices revealed that the two groups had significantly different covariance matrices ($F=1.70$, $p<.001$). The test means also differed significantly across the two groups ($F=3.75$, $p<.001$). Univariate F-tests indicated that 20 of the 34 variables differed between group at the $p<.05$ level.

To test whether ability level accounted for these differences between the two groups of students, We conducted a multivariate analysis of covariance (MANCOVA) using the students' pre-enlistment ASVAB scores as covariates. After partialling out the variance due to ASVAB scores, the test for homogeneity of covaiances matrices revealed different matrices for the two groups

(F=1.48, p<.001). Means also differed across the two groups after accounting for variance due to ASVAB scores (F=3.20, p<.001). These results suggest that the noted differences between the two groups are due to something other than differences in abilty, and they indicate that the two samples come from two distinct populations.

To further evaluate the conclusion of differences between groups, we computed effect sizes (ES) as measures of the pratical significance of the differences between the unadjusted means across groups. Cohen and Cohen (1977) state that .2 represents a small effect size, .5 is medium, and .8 is large. For the total of total of 34 comparisons between the AV groups, we found 17 ESs within the .00 to .19 range and 17 ESs within the .20 to .49 range. These results show that 100% of the ESs fall below a value of .50. Thus, while the MANOVA tests indicate that the groups differ from one another in terms of statistical significance, the ESs suggest small magnitudes of the differences, in terms of pratical significance.

In addition to testing for differences due to the introduction of a new version of Part 4, we also tested for differences due to including versus excluding labs from the FSG. We compared Groups 2a and 2b using a multivariate analysis of variance (MANOVA) to test the covariance matrices of the test scores. A test for homogeneity of covariance matrices revealed that the two groups had significantly different covariance matrices (F=1.32, p<.001). The test means did not differ across the two groups (F=1.32, p=.136).

To test whether ability level accounted for these differences between the two groups of students, we conducted a multivariate analysis of covariance (MANCOVA) using the students' pre-enlistment ASVAB scores as covariates. After partialling out the variance due to ASVAB scores, the test for homogeneity of

covaiances matrices revealed different matrices for the two groups ($F=1.15$, $p<.001$). Means did not differ across the two groups after accounting for variance due to ASVAB scores ($F=1.37$, $p=.106$). However, because of the significant differences found between the covariance matrices, we treated the groups separately. These results suggest that the noted differences between the two groups is due to something other than differences in abilty.

Based on the differences due to the new version of Part 4 and the two methods of computing the FSG, we analyzed each of the three groups separately. We present the results for Group 1 followed by the results for Groups 2a and 2b.

Table 25 presents the descriptive statistics for the variables in Group 1. We conducted a factor analysis on the set of knowledge, performance, and comprehensive test variables. The scree test and factor loadings indicated a two-factor solution. Table 26 shows the communalities, factor loadings, and factor score coefficients. Based on the results of the factor analysis, we labeled the first factor Advanced Avionics and the second factor Basic Avionics.

To examine whether an Advanced Avionics versus a Basic Avionics distinction could explain aspects of school performance, we created a composite variable based on the sum of all the Advanced Avionics tests (Maint. Instruction Manual test to Basic Intergrated Weapons test) and a composite variable based on the sum of all the Basic Avionics tests (General Math test to AC Theory test). Additional composites included the Sum1 and Sum2 composites which took a simple average of all the tests that loaded .30 or greater on either Factor 1 or Factor 2, respectively. We also calculated a composite based on all Knowledge tests (comprehensive tests included), a composite based on all Performance tests, and a composite based on all Labs. Because the AV school computed the FSG using a 70 as the minimum score, we calculated a second final school grade (FSG) using

Table 25

Descriptive Statistics for AV Variables-Group 1

Variable	n	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
General Math-K	234	87.179	12.796	-1.514	2.079	37.50	100.00
Intro/DC Circuit-L	234	93.189	7.305	-2.458	7.124	53.20	100.00
DC Circuits-K	234	84.797	9.530	-0.579	-0.149	55.00	100.00
Parallel Circuits-L	233	93.240	5.333	-1.133	1.103	71.80	100.00
Series/Parallel Circuits-K	233	84.421	12.245	-1.194	1.905	37.50	100.00
Series/Parallel DC T/S-L	231	93.402	7.509	-3.430	15.461	45.60	100.00
Voltage Dividers-L	230	93.039	9.539	-4.159	27.506	10.00	100.00
T/S DC Circuits-P	231	95.311	7.058	-2.222	6.836	52.00	100.00
Comprehensive 1	230	82.484	10.615	-0.356	-0.581	52.00	100.00
Test Equipment-L	231	95.750	8.736	-5.049	40.829	10.00	100.00
R/C Circuit Analysis-L	231	93.010	9.205	-2.163	5.983	46.20	100.00
AC Concepts/RC Circuit/OSC-K	231	82.076	12.219	-0.589	-0.522	48.00	100.00
R/L Circuits. Transf.-L	230	95.571	5.139	-4.683	35.287	47.70	100.00
Inductance-K	230	81.760	11.876	-0.530	-0.264	48.60	100.00
Series/Parallel Circuits-L	228	92.729	9.689	-2.362	5.877	50.00	100.00
RC/RL Circ. Filt.-P	228	97.693	4.782	-4.301	26.345	58.00	100.00
Comprehensive 2	228	79.044	9.793	0.055	-0.813	56.00	100.00
Amplifiers-L	228	98.521	5.334	-7.911	73.395	41.60	100.00
Semiconductors-K	228	85.417	9.421	-0.654	0.152	55.00	100.00
Limiters & Clampers-L	228	98.907	6.154	-13.446	194.087	10.00	100.00
Solid State-K	228	85.876	10.199	-1.722	7.120	20.00	100.00
OSCs & Voltage Regulators-L	228	98.984	1.774	-2.526	7.187	90.00	100.00
Pwr. Supplies/Naval Av. Maint.-K	228	84.058	10.212	-0.992	3.707	25.70	100.00
AM Receivers-L	228	97.480	13.728	-6.357	39.575	10.00	100.00
AM Communication Theory-K	228	86.009	8.863	-0.697	0.271	57.50	100.00
AM Xmtr. RF Amp. & 1st Rcvr Mixer-L	228	97.470	3.663	-1.673	2.913	80.00	100.00
1st IF Amp. & 2nd Rcvr Mixer-L	228	97.680	4.089	-3.136	15.047	67.50	100.00
T/S: Rcvr-L	228	94.727	8.063	-2.305	6.603	48.70	100.00
T/S: Rcvr-P	228	94.936	9.049	-3.712	19.251	27.00	100.00
AM Xmtr-K	228	80.976	10.987	-0.650	1.065	30.00	100.00
OSC. Xmtr-L	228	98.708	4.739	-10.401	132.072	36.50	100.00
Power. Volt reg.-L	228	99.421	1.562	-3.974	18.520	89.00	100.00
OSC. Power-K	228	85.954	8.074	-0.506	-0.070	62.50	100.00
Trouble/S-L	228	97.432	7.812	-6.991	69.808	10.00	100.00
AM Xmtr-P	228	96.872	6.867	-6.903	72.711	19.00	100.00
Comprehensive 3	228	82.219	8.591	-0.380	0.399	54.00	100.00
Integrators & Differentrs-L	228	99.211	8.411	-10.606	111.464	10.00	100.00
Blocking OSCs & Multivibrators-L	228	98.033	12.117	-6.166	37.274	10.00	100.00
Elec.Mech/Solid State-K	228	80.998	9.705	-0.310	-0.280	52.50	100.00
Sweep Generators-L	228	99.189	8.415	-10.582	111.110	10.00	100.00
Power Supplies-K	228	84.035	8.112	-0.335	0.331	55.00	100.00
Logic Gates-L	227	99.559	4.692	-10.582	110.964	49.90	100.00
Logic Gates-K	228	88.918	7.988	-1.015	1.246	54.30	100.00
Maint. Instruction Manual-K	228	88.759	11.639	-3.424	14.974	26.70	100.00
Pwr.Supply/Blk.Diag.Anlys-K	227	84.220	9.181	-0.842	0.944	45.00	100.00
3-Phase Pwr.Supply/Circ.Anlys.-K	227	86.991	7.962	-1.292	3.890	42.90	100.00
T/S Ant, Xmtr, & Rcvr-L	227	99.814	1.613	-8.627	73.312	85.30	100.00
Short-slot Hybrid Mixer-K	227	85.253	10.897	-1.004	1.257	42.50	100.00
T/S Spec. Circuits-P	227	94.876	5.190	-1.473	2.708	70.00	100.00
Comprehensive 4	227	89.514	7.974	-2.021	7.358	47.50	100.00
Clocks/Counters,Adders-L	227	96.819	15.553	-5.428	27.845	10.00	100.00
Multipliers-L	227	96.868	15.568	-5.422	27.792	10.00	100.00
Digital Circuits-P	227	97.899	4.564	-4.083	24.522	60.00	100.00
Registers/Multipliers/Dividers-K	227	84.722	9.664	-1.469	5.130	28.60	100.00
Signals.Encoders,& Decoders-L	227	99.733	0.903	-3.415	10.341	96.00	100.00

Table 25 (Continued)

Variable	n	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
Multipliers-Subtractors/Signals-K	227	98.899	3.352	-3.607	13.539	80.00	100.00
Computer Coding-L	227	99.611	1.172	-2.955	7.365	95.00	100.00
Comp. Basics/Electrostatic Disch.-K	227	83.599	9.516	-0.500	0.554	42.50	100.00
Corrosion. Prev. Maint.-K	226	92.223	8.011	-1.806	4.870	51.90	100.00
Soldering-K	226	99.719	0.864	-3.776	16.150	94.20	100.00
Wire Repair-L	226	99.665	1.077	-3.190	9.192	94.20	100.00
Wire Repair-P	226	95.748	6.030	-4.085	25.291	50.00	100.00
Infrared/Laser Principles-K	226	86.319	9.226	-0.714	0.391	56.00	100.00
Basic Integrated Weapons-K	225	88.592	10.945	-0.998	0.572	53.30	100.00

Table 26

Comunalities, Factor Loadings and Factor Score Coefficients for AV Variables - Group 1

Variable	Communality	Factor Loadings		Factor Score Coefficients	
		Factor 1: Adv Avionics	Factor2: Bsc Avionics	Factor 1: Adv Avionics	Factor 2: Bsc Avionics
General Math-K	.325	189	.538	-.026	.080
DC Circuits-K	.429	.330	.565	-.026	.101
Series/Parallel Circuits-K	.469	.254	.636	-.055	.129
T/S DC Circuits-P	.248	.071	.493	-.062	.099
Comprehensive 1	.612	.286	.728	-.065	.199
AC Concepts/RC Circuit/OSC-K	.675	.373	.732	-.071	.241
Inductance-K	.587	.402	.652	-.015	.131
RC/RL Circ. Filt.-P	.022	.133	.067	.012	.007
Comprehensive 2	.580	.392	.653	-.002	.128
Semiconductors-K	.400	.432	.463	.036	.044
Solid State-K	.277	.336	.405	.011	.042
Pwr. Supplies/Naval Av. Maint.-K	.324	.427	.377	.056	.009
AM Communication Theory-K	.398	.480	.409	.057	.033
T/S: Rcvr-L	.075	.178	.207	.012	.014
AM Xmtr-K	.398	.388	.497	.019	.068
OSC.Power-K	.400	.439	.456	.024	.056
AM Xmtr-P	.109	.053	.326	-.022	.048
Comprehensive 3	.410	.482	.421	.055	.027
Elec.Mech/Solid State-K	.372	.516	.326	.073	-.005
Power Supplies-K	.369	.443	.416	.018	.056
Maint. Instruction Manual-K	.113	.336	.002	.063	-.040
Pwr.Supply/Blk.Diag.Anlys-K	.540	.708	.196	.208	-.107
3-Phase Pwr.Supply/Circ.Anlys.-K	.512	.714	.042	.221	-.142
Short-slot Hybrid Mixer-K	.540	.708	.198	.205	-.104
T/S Spec. Circuits-P	.127	.320	.155	.028	.002
Coomprehensive 4	.406	.635	.053	.156	-.105
Digital Circuits-P	.035	-.091	.162	-.031	.041
Registers/Multipliers/Dividers-K	.331	.421	.392	.040	.021
Multipliers-Subtractors/Signals-K	.021	.084	.119	-.007	.024
Comp. Basics/Electrostatic Disch.-K	.481	.594	.357	.114	-.006
Corrosion. Prev. Maint.-K	.152	.343	.186	.050	-.009
Wire Repair-P	.009	.040	-.085	.020	-.021
Infrared/Laser Principles-K	.311	.555	.056	.122	-.081
Basic Integrated Weapons-K	.104	.252	.202	.033	-.006

Note. n = 225

the initial test scores, and listed both as composite variables. Table 27 shows the descriptive statistics for the composite variables.

Next, we computed Pearson correlation coefficients for the composite variables. Table 28 presents the composite variable intercorrelations. Because FSG and FSG2 correlate .98, this offers no support for using initial test scores to compute FSG.

Advanced Avionics correlates highest (.95) with Factor1, followed by Sum1 (.83). Similiarly, Basic Avionics correlates highest (.91) with Factor2, followed closely by Sum2 (.85). These findings support using the logical combinations of tests to assess the dimensions reflected in the factor analyses.

Finally, FSG corrlelates .77 with the Advanced Avionics and .87 with Basic Avionics. Considering the moderate correlations of FSG with Factors 1 and 2 (.72 and .75), these findings do not support FSG as a unidimensional criterion. Instead, these findings suggest using the composites Advanced Avionics and Basic Avionics.

Results for Groups 2a and 2b. Table 29 presents the descriptive statistics for Group 2a and Table 30 presents the descriptive statistics for Group 2b. Because of the small sample sizes in both groups, a factor analysis procedure could not extract factors for either group. As a result, we computed composite variables based on the same composite variables computed for Group 1. Table 31 and Table 32 present the descriptive statistics for the composite variables for Group 2a and Group 2b, respectively.

Next, we examined the patterns of correlations among the composite variables for each group. Table 33 presents the correlation matrix for both Groups 2a and 2b. For both groups, FSG and FSG2 correlate .97 to .99 which offers no support for using initial test scores to compute FSG. Also, for Group

Table 27

Descriptive Statistics for AV Composite Variables - Group 1

Composite	n	Rel[a]	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
Sum1[b]	226	.928	85.216	5.772	0.121	-0.712	72.33	97.47
Sum2[c]	227	.927	85.019	6.253	0.341	-0.687	69.69	98.63
FSG[d]	234	N/A	89.669	4.865	-1.838	9.048	60.60	98.60
FSG2[e]	225	.894	88.260	4.555	0.123	-0.756	77.54	98.15
Knowledge[f]	225	.936	85.158	5.844	0.165	-0.772	72.19	97.97
Performance[g]	226	.281	96.539	2.448	-1.455	4.527	82.25	100.00
Lab[h]	226	.861	97.174	2.181	-2.248	7.323	83.90	99.73
Adv Avionics[i]	226	.817	87.963	5.676	-0.692	1.068	64.94	98.59
Bsc Avionics[j]	228	.884	84.960	7.824	-0.224	-0.906	68.20	99.69

[a]These are composites based on communality estimates and the procedures described in the text.
[b]Sum1: Average of all variables loading .30 or greater on Factor 1.
[c]Sum2: Average of all variables loading .30 or greater on Factor 2.
[d]FSG: Final School Grade computed by the AV school (see Appendix E).
[e]FSG2: Final School Grade computed using initial test scores.
[f]Knowledge: Average of all Knowledge tests.
[g]Performance: Average of all Performance tests.
[h]Lab: Average of all Lab tests
[i]Adv Avionics: Average of Maint. Instructional Manual to Basic Intergrated Weapons tests.
[j]Bsc Avionics: Average of General Math to AC Theory tests.

Table 28

Correlations Amoung AV Composites and Factors - Group 1

Comp	Factor1	Factor2	Sum1[a]	Sum2[b]	FSG[c]	FSG2[d]	Knowledge[e]	Perform[f]	Lab[g]	Adv Avionics[h]
Factor2	.13									
Sum1	.83	.64								
Sum2	.62	.85	.94							
FSG	.72	.75	.96	.96						
FSG2	.79	.69	.99	.96	.98					
Knowledge	.78	.71	.99	.97	.98	.99				
Perform	.27	.52	.49	.55	.58	.58	.49			
Lab	.19	.24	.26	.27	.30	.30	.28	.18		
Adv Avionics	.95	.24	.86	.67	.77	.83	.82	.34	.23	
Bsc Avionics[i]	.43	.91	.82	.92	.87	.84	.87	.51	.30	.54

Note. n = 225
[a]Sum1: Average of all variables loading .30 or greater on Factor 1.
[b]Sum2: Average of all variables loading .30 or greater on Factor 2.
[c]FSG: Final School Grade computed by the AV school
[d]FSG2: See Appendix E for computation of Final School Grade
[e]Knowledge: Average of all Knowledge tests.
[f]Performance: Average of all Performance tests.
[g]Lab: Average of all Lab tests
[h]Adv Avionics: Average of Maint. Instructional Manual to Basic Intergrated Weapons tests.
[i]Bsc Avionics: Average of General Math to AC Theory tests.

Table 29

Descriptive Statistics for AV Variables - Group 2a

Variable	n	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
General Math-K	101	88.218	13.136	-1.755	3.060	40.00	100.00
Intro/DC Circuit-L	100	93.740	7.540	-2.478	6.639	62.40	100.00
DC Circuits-K	100	87.825	8.293	-0.798	0.294	65.00	100.00
Parallel Circuits-L	100	93.699	5.312	-0.707	-0.503	80.10	100.00
Series/Parallel Circuits-K	100	86.650	11.148	-1.014	0.811	50.00	100.00
Series/Parallel DC T/S-L	99	94.816	9.507	-6.069	45.826	17.50	100.00
Voltage Dividers-L	99	95.385	5.049	-1.252	1.401	76.50	100.00
T/S DC Circuits-P	99	96.030	6.429	-1.774	2.705	72.00	100.00
Comprehensive 1	99	86.437	9.243	-0.718	0.470	57.80	100.00
Test Equipment-L	99	97.814	5.319	-4.414	23.622	62.00	100.00
R/C Circuit Analysis-L	99	94.839	8.700	-2.564	6.987	54.90	100.00
AC Concepts/RC Circuit/OSC-K	98	84.133	11.042	-0.697	-0.058	52.50	100.00
R/L Circuits Transf.-L	98	96.395	4.762	-3.095	13.458	68.20	100.00
Inductance-K	98	81.893	11.935	-0.543	-0.214	48.60	100.00
Series/Parallel Circuits-L	97	96.598	5.348	-3.240	13.557	68.00	100.00
RC/RL Circ. Filt.-P	97	98.392	2.819	-1.666	1.788	88.00	100.00
Comprehensive 2	97	81.423	10.587	-0.557	0.282	48.00	100.00
Amplifiers-L	95	99.712	1.053	-4.058	16.395	94.10	100.00
Semiconductors-K	97	86.010	11.325	-1.312	1.796	42.50	100.00
Limiters & Clampers-L	96	99.724	0.984	-3.639	12.320	95.00	100.00
Solid State-K	96	86.452	9.973	-0.466	-0.599	60.00	100.00
OSCs & Voltage Regulators-L	96	99.906	0.327	-3.710	14.496	98.00	100.00
Pwr. Supplies/Naval Av. Maint.-K	95	85.892	9.183	-0.353	-0.467	60.00	100.00
AM Receivers-L	95	99.220	7.602	-9.747	95.000	25.90	100.00
AM Communication Theory-K	95	86.868	9.432	-1.151	1.486	55.50	100.00
AM Xmtr. RF Amp. & 1st Rcvr Mixer-L	94	99.843	0.733	-5.343	30.966	94.70	100.00
1st IF Amp. & 2nd Rcvr Mixer-L	94	99.777	0.941	-4.523	20.209	95.00	100.00
T/S: Rcvr-L	94	98.006	6.469	-3.552	12.004	70.00	100.00
T/S: Rcvr-P	94	96.500	8.061	-4.985	33.995	36.00	100.00
AM Xmtr-K	94	84.681	9.866	-0.512	0.286	55.00	100.00
OSC. Xmtr-L	93	99.944	0.539	-9.644	93.000	94.80	100.00
Power. Vol reg.-L	93	99.980	0.197	-9.644	93.000	98.10	100.00
OSC. Power-K	93	87.312	9.046	-1.211	1.824	55.00	100.00
Trouble/S-L	93	99.271	3.701	-5.189	25.950	79.10	100.00
AM Xmtr-P	93	97.613	6.656	-4.378	21.484	60.00	100.00
Comprehensive 3	93	84.231	8.760	-0.184	-0.478	62.00	100.00
Elec.Mech/Solid State-K	93	83.548	9.400	-0.408	-0.251	60.00	100.00
Switching Power Supplies-L	93	98.935	10.266	-9.644	93.000	1.00	100.00
Power Supplies-K	93	85.323	7.899	-0.356	-0.539	67.50	100.00
Logic Gates-L	93	95.161	20.410	-4.022	14.488	10.00	100.00
Logic Gates-K	93	90.932	7.501	-0.960	0.821	65.70	100.00
Maint. Instruction Manual-K	93	92.940	4.806	-0.316	-0.505	82.10	100.00
Pwr.Supply/Blk.Diag.Anlys-K	93	86.860	9.404	-0.382	-0.844	65.00	100.00
3-Phase Pwr.Supply/Circ.Anlys.-K	93	88.577	10.032	-2.153	9.960	32.10	100.00
Short-slot Hybrid Mixer-K	93	86.842	9.372	-0.722	0.348	55.00	100.00
Circ.Anlys., Rcvr Circuit-K	89	87.449	10.020	-0.574	-0.534	62.50	100.00
T/S Spec. Circuits-P	93	95.935	6.506	-2.101	4.370	69.00	100.00
Comprehensive 4	93	87.503	8.053	-0.526	-0.216	62.50	100.00
Clocks/Counters,Adders-L	93	99.677	0.823	-2.322	3.920	97.00	100.00
Multipliers-L	93	99.624	0.955	-2.240	3.270	97.00	100.00
Digital Circuits-P	93	99.194	2.086	-2.787	7.693	90.00	100.00
Registers/Multipliers/Dividers-K	93	85.802	9.970	-0.696	0.686	48.60	100.00
Signals,Encoders,& Decoders-L	93	99.828	0.816	-4.579	19.385	96.00	100.00
Multipliers-Subtractors/Signals-K	93	98.946	3.181	-3.919	17.480	80.00	100.00
Computer Coding-L	93	99.871	0.612	-4.579	19.385	97.00	100.00

Table 29 (Continued)

Variable	n	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
Comp. Basics/Electrostatic Disch.-K	93	85.989	9.217	-0.462	-0.792	65.00	100.00
Corrosion, Prev. Maint.-K	93	92.322	7.524	-1.552	3.593	59.30	100.00
Soldering-K	93	99.828	0.816	-4.579	19.385	96.00	100.00
Wire Repair-L	93	99.871	0.612	-4.579	19.385	97.00	100.00
Wire Repair-P	93	95.742	5.211	-1.909	3.911	75.00	100.00
Infrared/Laser Principles-K	93	90.323	8.634	-0.832	-0.189	68.00	100.00
Basic Integrated Weapons-K	92	92.310	8.723	-1.183	0.658	66.70	100.00

Table 30

Descriptive Statistics for AV Variables - Group 2b

Variable	n	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
General Math-K	115	84.130	15.232	-1.552	2.440	22.50	100.00
DC Circuits-K	110	83.136	10.060	-0.704	0.224	52.50	100.00
Series/Parallel Circuits-K	110	84.091	13.331	-1.101	0.782	42.50	100.00
T/S DC Circuits-P	108	94.139	8.564	-2.267	6.105	54.00	100.00
Comprehensive 1	108	83.541	11.743	-1.218	3.493	31.10	100.00
AC Concepts/RC Circuit/OSC-K	105	82.071	13.452	-1.059	0.466	40.00	100.00
Inductance-K	98	83.266	11.248	-0.597	-0.251	51.40	100.00
RC/RL Circ. -PFilt.	94	97.011	5.654	-4.257	26.554	57.00	100.00
Comprehensive 2	94	82.234	9.421	-0.678	1.841	44.00	100.00
Semiconductors-K	92	86.646	8.257	-0.550	0.159	60.50	100.00
Solid State-K	91	86.749	9.080	-0.416	-0.388	60.00	100.00
Pwr. Supplies/Naval Av. Maint.-K	91	84.645	9.776	-0.468	0.061	54.30	100.00
AM Communication Theory-K	89	88.511	8.383	-1.362	2.139	60.00	100.00
T/S: Rcvr-L	85	97.941	3.543	-1.576	0.927	89.00	100.00
AM Xmtr-K	85	86.324	8.234	-0.372	-0.447	65.00	100.00
OSC. Power-K	85	88.618	6.552	-0.260	-0.650	75.00	100.00
AM Xmtr-P	85	98.753	3.128	-2.459	4.396	89.00	100.00
Comprehensive 3	85	85.912	8.477	-0.792	0.147	63.30	100.00
Elec.Mech/Solid State-K	85	85.353	8.601	-0.665	0.264	60.00	100.00
Power Supplies-K	85	86.676	7.414	-0.456	-0.418	67.50	100.00
Maint. Instruction Manual-K	84	93.025	5.726	-1.443	3.425	67.90	100.00
Pwr.Supply/Blk.Diag.Anlys-K	84	86.726	8.159	-0.509	-0.423	70.00	100.00
3-Phase Pwr.Supply/Circ.Anlys.-K	84	89.074	8.264	-0.863	0.543	64.30	100.00
Short-slot Hybrid Mixer-K	84	85.060	9.863	-0.702	-0.036	60.00	100.00
Circ.Anlys., Rcvr Circuit-K	84	86.410	9.418	-0.641	0.377	54.20	100.00
T/S Spec. Circuits-P	84	96.083	7.159	-3.009	10.383	60.00	100.00
Comprehensive 4	84	87.887	8.108	-1.262	2.110	57.50	100.00
Digital Circuits-P	83	98.554	2.860	-2.426	6.681	85.00	100.00
Registers/Multipliers/Dividers-K	83	87.157	8.604	-0.636	-0.042	62.90	100.00
Multipliers-Subtractors/Signals-K	83	99.398	1.814	-3.127	9.971	90.00	100.00
Comp. Basics/Electrostatic Disch.-K	83	86.235	8.350	-0.696	0.387	62.50	100.00
Corrosion, Prev. Maint.-K	83	92.288	7.152	-0.750	-0.132	74.10	100.00
Wire Repair-P	83	95.855	5.469	-1.921	4.250	75.00	100.00
Infrared/Laser Principles-K	83	90.795	7.771	-0.646	-0.413	72.00	100.00
Basic Integrated Weapons-K	83	90.677	10.611	-1.941	4.256	53.30	100.00

Table 31

Descriptive Statistics for AV Composite Variables - Group 2a

Composite	n	Rel[a]	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
Sum1[c]	93	.979	86.947	6.006	0.070	-0.723	73.66	98.87
Sum2[c]	93	.979	86.791	6.498	-0.139	-0.660	72.53	99.14
FSG[d]	101	N/A	90.765	4.948	-1.231	3.402	69.60	99.30
FSG2[e]	88	.972	89.900	4.820	-0.174	-0.663	78.01	99.21
Knowledge[f]	88	.982	87.109	5.196	-0.071	-0.873	73.80	99.11
Performance[g]	93	.831	97.335	2.768	-3.230	15.054	80.63	100.00
Lab[h]	93	.882	97.569	2.043	-1.396	1.571	91.22	100.00
Adv Avionics[i]	93	.925	89.616	5.094	-0.355	-0.517	76.84	98.22
Bsc Avionics[j]	97	.962	86.764	7.704	-0.507	-0.373	66.79	99.38

[a]These are composites based on communality estimates and the procedures described in the text.
[b]Sum1: Average of all variables loading .30 or greater on Factor 1.
[c]Sum2: Average of all variables loading .30 or greater on Factor 2.
[d]FSG: Final School Grade computed by the AV school
[e]FSG2: See Appendix E for computation of Final School Grade
[f]Knowledge: Average of all Knowledge tests.
[g]Performance: Average of all Performance tests.
[h]Lab: Average of all Lab tests
[i]Adv Avionics: Average of Maint. Instructional Manual to Basic Intergrated Weapons tests.
[j]Bsc Avionics: Average of General Math to AC Theory tests.

Table 32

Descriptive Statistics for AV Composite Variables - Group 2b

Composite	n	Rel[a]	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
Sum1[b]	83	.951	87.635	4.810	-0.122	-0.882	77.17	96.71
Sum2[c]	83	.953	87.531	5.355	-0.061	-0.938	76.60	97.69
FSG[d]	115	N/A	86.559	11.130	-3.098	12.521	22.50	97.30
FSG2[e]	83	.940	88.834	4.666	0.207	-0.818	77.85	97.17
Knowledge[f]	83	.958	87.557	4.890	-0.198	-0.844	77.41	96.58
Performance[g]	83	.552	97.295	2.013	-1.416	2.208	89.38	99.75
Adv Avionics[h]	83	.828	89.680	4.214	-0.281	-0.571	79.92	97.59
Bsc Avionics[i]	94	.913	86.045	7.565	-0.510	-0.433	65.40	98.79

[a]These are composites based on communality estimates and the procedures described in the text.
[b]Sum1: Average of all variables loading .30 or greater on Factor 1.
[c]Sum2: Average of all variables loading .30 or greater on Factor 2.
[d]FSG: Final School Grade computed by the AV school (see Appendix E).
[e]FSG2: Final School Grade computed using initial test scores.
[f]Knowledge: Average of all Knowledge tests.
[g]Performance: Average of all Performance tests.
[h]Adv Avionics: Average of Maint. Instructional Manual to Basic Intergrated Weapons tests.
[i]Bsc Avionics: Average of General Math to AC Theory tests.

Table 33

Correlations Among AV Composite Variables - Groups 2a & 2b

Composite	Sum1[a]	Sum2[b]	FSG[c]	FSG2[d]	Knowledge[e]	Perform[f]	Lab[g]	Adv Avionics[h]	Bsc Avionics[i]
Sum1	-	.94	.97	.95	.98	.52	n/a	.84	.78
Sum2	.97	-	.98	.99	.97	.56	n/a	.67	.91
FSG	.98	.98	-	.98	.98	.64	n/a	.78	.86
FSG2	.99	.97	.99	-	.97	.60	n/a	.70	.90
Knowledge	.99	.98	.99	.99	-	.50	n/a	.80	.84
Perform	.51	.54	.60	.58	.49	-	n/a	.39	.56
Lab	.46	.46	.43	.45	.46	.13	-	n/a	n/a
Adv Avionics	.91	.81	.88	.91	.89	.47	.35	-	.50
Bsc Avionics	.88	.94	.91	.88	.91	.54	.46	.69	-

Note. Coefficients below the diagonal correspond to Group 2a ($n = 88$). Coefficients above the diagonal correspond to Group 2b ($n = 83$).

[a]Sum1: Average of all variables loading .30 or greater on Factor 1.

[b]Sum2: Average of all variables loading .30 or greater on Factor 2.

[c]FSG: Final School Grade computed by the AV school (see Appendix E).

[d]FSG2: Final School Grade computed using initial test scores.

[e]Knowledge: Average of all Knowledge tests.

[f]Performance: Average of all Performance tests.

[g]Lab: Average of all Lab tests

[h]Adv Avionics: Average of Maint. Instructional Manual to Basic Intergrated Weapons tests.

[i]Bsc Avionics: Average of General Math to AC Theory tests.

Advanced Avionics correlates .88 with FSG and Basic Avionics correlates .91 with FSG. These findings support using FSG as an indicator of performance on Advanced Avionics tests and Basic Avionics tests.

For Group 2b, FSG and FSG2 correlate .98 which offers no support for using initial test scores to compute FSG, Sum1 and Sum2 correlate .97 and .94, offering no support for 2 different factors. Indeed, correlations with Sum1 or Sum2 with FSG, Knowledge, Advanced Avionics, and Basic Avionics range from .81 to .98. The lowest correlations with Sum1 and Sum2 are with the Performance and Lab composites (.46 to .56). These results support using the Performance and Lab composites.

Advanced Avionics correlates .78 to .88 with FSG and Basic Avionics correlates .86 to .91 with FSG. These findings support using FSG as an indicator

of performance on Basic Avionics tests but suggest using a separate indicator for performance on the Advanced Avionics tests.

Recommendations. For Group 1, in addition to FSG, use the average of all Advanced Avionics tests and the average of all Basic Avionics tests. For Groups 2a and 2b, in addition to FSG, use an average of all Performance tests and an average of all Lab tests (except where not available for Group 2b).

Electrician's Mate (EM)

Description of Variables. Table 34 presents the EM tests and their corresponding descriptions. The EM school assesses student progress using written knowledge and comprehensive tests. The tests have a valid range of 0 to 100. The EM school separates the curriculum into 3 phases. Phase 1 covers the first 9 tests, ending after the first comprehensive test. This phase addresses EM basics. The next 11 tests comprise Phase 2, ending with the third comprehensive exam. Phase 3 covers the remaining 4 tests. Phase 2 and Phase 3 address EM technical material. Table 34 points out a change in test order for 3 of the tests (Lighting, Small Craft, and Auxilliary).

The EM school requires a minimum passing score of 75% for each test. The Academic Review Board (ARB) forms a recommendation as to the status of each student who fails a test. ARB often permits such students to retest. ARB reexamines students who fail the retest and determines how the student will proceed. The instructor assigns the minimum passing score to those students who pass the retest, and the school uses that minimum score in calculating the final school grade (FSG). Although the instructor enters a score of 75 for all successful retests, for the purpose of the present study, RGI entered all initial test scores into the database.

The EM school uses a weighted average of the test scores to determine the final FSG. Each knowledge test contributes 4% and each comprehensive test contributes 6%. The instructors do not include the Math Pretest score (test #500) in determining the FSG.

Sample. The initial sample contained 961 students who began training between January 1990 and October 1991. We excluded students who did not take all tests from some analyses. Consequently, our final sample contained 891 cases.

Table 34

Descriptions of EM Variables

Test No.	Description (Name)
Phase 1	
500	**Knowledge Test:** Math pretest to determine skills upon course entrance (FSG does not include this test) (Math Pretest)
001	**Knowledge Test:** General math, scientific notation, trigonometry (Math)
002	**Knowledge Test:** Safety: First aid, electrical safety, CPR (Safety)
004	**Knowledge Test:** Basics: Ohm's law, power schematics, fluke 77, AN circuit construction, DC series circuits (Basics)
005	**Knowledge Test:** DC parallel circuit construction & variational analysis, series/parallel characteristics, DC troubleshooting (DC Circuit)
006	**Knowledge Test:** AC generation, waveform analysis/oscilloscope, electromagnetism, miscellaneous test equipment (AC Circuit)
007	**Knowledge Test:** Inductance fundamentals/reactance, RL circuits, transformers (Inductance)
008	**Knowledge Test:** Capacitance fundamentals/reactance, RC circuits, RLC circuits (Capacitance)
009	**Comprehensive Knowledge Test 1:** Content from tests 002 to 008 (Comp 1)
Phase 2	
010	**Knowledge Test:** Engineering Admin: Tag-out, preventative maint., personnel qualification syst./tools/fasteners, cables (Engineering)
011	**Knowledge Test:** Generators: Steam cycle, AC & DC generators, generator maintenance/technical manuals (Generators)
012	**Knowledge Test:** Distribution: Introduction to distribution, EOSS, switchboards/shore power (Distribution)
013	**Knowledge Test:** Motors: DC & AC motors, motor maintenance (Motors)
014	**Knowledge Test:** Controllers: Introduction to controllers, AC controllers (Controllers)
015	**Comprehensive Knowledge Test 2:** Content from tests 010 to 014 (Comp 2)
016	**Knowledge Test:** AC/R & Galley: Refrigeration & air conditioning, galley auxiliary (Galley)

On March 6, 1991, the school changed the sequence of the Lighting, Small Craft, and Auxilliary tests. Form 1 covers students entering the school before this date. Form 2 addresses students entering the school after March 6, 1991.

017	**Knowledge Test:**
	Form 1: Lighting distribution & navigational lighting (Lighting)
	Form 2: Smallcraft: Batteries, starting/charging system (Small Craft)
018	**Knowledge Test:**
	Form 1: Smallcraft: Batteries, starting/charging system (Small Craft)
	Form 2: Miscellaneous Auxiliary: Degaussing, cathodic protection, valve operators (Auxilliary)
019	**Knowledge Test:**
	Form 1: Miscellaneous Auxiliary: Degaussing, cathodic protection, valve operators (Auxilliary)
	Form 2: Lighting distribution & navigational lighting (Lighting)
020	**Comprehensive Knowledge Test 3:** Content from tests 016 to 019
Phase 3	
021	**Knowledge Test:** Electronics: P.N. junction theory, special devices, transistor theory (Elect 1)
022	**Knowledge Test:** Electronics: Power supplies, transformers & rectifiers, AMP operation/transistor configuration, integrated circuits, introduction to logics (Elect 2)
023	**Knowledge Test:** Elevators: Introduction to basic components, power supply & signal converters, operations of gate circuits & set-reset/pulser/stepper/input devices/magnetic controller, flow charts & elevator operations (Elevators)
024	**Comprehensive Knowledge Test 4:** Content from test #002 to #023 (Comp 4)

Results and Discussion. We began by testing for an order effect due to the change in test order of the Lighting, Small Craft and Auxilliary exams. We separated the students into Form 1 and Form 2, based upon whether they entered the school before or after the test order change. We then conducted a multivariate analysis of variance (MANOVA) to test the correlation matrices of the test scores. A test for homogeneity of covariance matrices revealed that the two forms had significantly different covariance matrices ($F=1.67$, $p < .001$). The test of means also differed significantly across the two forms ($F=6.97$, $p < .001$). These results suggest that the two samples come from two distinct populations. Univariate F-tests revealed nine of the tests to differ between forms at the $p < .05$ level (Math Pretest, Math, DC Circuit, AC Circuit, Capacitance, Distribution, Galley, Lighting, and Auxilliary). In addition to two of the re-ordered tests (Small Craft and Lighting), these include seven exams occurring earlier in the curriculum. This finding suggests that, in addition to the test re-ordering, the two groups also differ in some other manner.

To test whether ability accounted for this difference, RGI conducted a multivariate analysis of covariance (MANCOVA) using the student's pre-enlistment ASVAB scores as covariates. After partialling out the variance due to ASVAB scores, a test for homogeneity of covariance matrices revealed different matrices for the two forms ($F=1.37$, $p < .001$). Test means also differed across the two forms after controlling for ASVAB scores ($F=7.33$, $p < .001$). These results suggest that the difference between the two groups is due to something other than differences in ability. Based on these findings, RGI analyzed each group separately.

To further evaluate the conclusion of differences between groups, we computed effect sizes (ES) as measures of the practical significance of the

Table 35

Descriptive Statistics for EM Variables

Test	n	Mean	Std Dev	Skew	Kurtosis	Min	Max
Form 1							
Math Pretest	748	57.444	16.137	.057	- .262	4.300	100.00
Math	759	93.361	7.801	-2.409	8.372	43.50	100.00
Safety	771	90.462	7.636	-1.013	.853	59.40	100.00
Basics	767	87.536	9.433	-1.279	2.273	39.60	100.00
DC Circuit	764	80.609	13.236	- .853	.421	32.50	100.00
AC Circuit	762	87.087	10.219	-1.439	4.356	12.50	100.00
Inductance	762	87.828	9.956	-1.042	1.110	40.00	100.00
Capacitance	762	87.025	11.538	-1.386	2.621	25.00	100.00
Comp 1	762	86.201	8.865	- .675	.091	55.80	100.00
Engineering	759	85.368	10.227	-1.070	2.053	26.30	100.00
Generators	758	87.421	9.172	-1.381	3.921	27.10	100.00
Distribution	755	88.266	8.354	-1.097	1.572	50.00	100.00
Motors	753	85.488	10.681	-1.140	2.386	30.00	100.00
Controllers	745	86.703	9.664	-1.222	2.544	29.20	100.00
Comp 2	744	87.059	7.772	- .875	1.322	50.00	100.00
Galley	743	85.869	10.591	-1.138	2.120	27.30	100.00
Lighting	741	87.632	10.479	-1.237	1.708	35.00	100.00
Small Craft	740	88.487	8.889	- .888	.555	52.80	100.00
Auxilliary	739	87.761	9.158	-1.161	2.351	33.30	100.00
Comp 3	739	84.209	10.115	- .730	.607	42.30	100.00
Elect 1	736	89.141	9.079	-1.356	3.503	27.50	100.00
Elect 2	734	89.444	9.262	-1.669	4.507	33.90	100.00
Elevators	731	87.758	10.754	-1.905	5.508	22.70	100.00
Comp 4	731	83.432	8.232	- .566	.229	53.00	100.00
Form 2							
Math Pretest	182	65.930	13.620	.054	- .017	24.60	98.60
Math	185	94.659	6.762	-2.448	8.141	56.50	100.00
Safety	187	89.736	8.550	-2.389	11.794	31.30	100.00
Basics	186	88.963	8.781	- .846	.106	60.40	100.00
DC Circuit	186	83.311	11.813	- .795	.853	33.30	100.00
AC Circuit	184	89.769	7.783	- .703	.026	65.00	100.00
Inductance	184	87.989	9.356	- .732	.033	55.00	100.00
Capacitance	184	89.582	9.599	-1.054	.682	60.40	100.00
Comp 1	184	86.553	8.711	- .647	- .349	65.40	100.00
Engineering	183	84.393	9.136	- .584	.176	57.90	100.00
Generators	182	88.871	8.470	-1.047	1.410	56.30	100.00
Distribution	181	90.244	7.183	-1.107	1.965	58.30	100.00
Motors	181	87.155	8.936	- .738	- .018	60.00	100.00
Controllers	181	87.945	8.437	- .872	1.042	52.10	100.00
Comp 2	181	87.521	6.640	- .476	- .068	63.90	100.00
Galley	181	83.664	11.488	- .684	.131	50.00	100.00
Sm Craft	181	84.309	10.352	- .709	.102	50.00	100.00
Auxilliary	181	87.039	9.403	- .847	.247	58.30	100.00
Lighting	181	83.560	10.796	- .775	.406	45.80	100.00
Comp 3	181	82.921	10.416	- .410	- .424	57.70	100.00
Elect 1	178	88.989	9.881	-2.105	9.391	25.00	100.00
Elect 2	178	88.842	9.229	-2.330	9.131	33.90	100.00
Elevators	178	88.278	8.405	- .908	.631	59.10	100.00
Comp 4	177	83.415	8.048	- .451	.213	54.00	99.00

differences between the unadjusted means across group. Cohen and Cohen (1977) state that .2 represents a small effect size, .5 is medium, and .8 is large. For a total of 24 comparisons between the EM groups, we found 16 ESs within the .00 to .19 range, 6 ESs within the .20 to .49 range, and 2 ESs within the .50 to .79 range. These results show that 91% of the ESs fall below a value of .50. Thus, while the MANOVA tests indicate that the groups differ from one another in terms of statistical significance, the ESs suggest small magnitudes of the differences, in terms of practical significance.

Within the EM curriculum, Form 1 contains students who took the course before the test order changes of March 6, 1991 (n=774). Form 2 contains students taking the EM course after the test re-ordering of March 6, 1991 (n=187). Form 1 included 58 cases with missing data. RGI excluded these cases from some of the analyses, resulting in a final sample of 716 cases for Form 1. Form 2 included 12 cases with missing data. Likewise, we excluded these cases from some of the analyses, resulting in a final sample size of 175 cases for Form 2.

RGI computed descriptive statistics for each of the tests. Table 35 presents these statistics, listing them separately for Form 1 and Form 2. Next, we conducted a factor analysis on each form separately. We included the set of all tests except Math Pretest in these analyses. School instructors indicated they gave this test prior to any instruction. Resulting scree tests and factor loadings for the two forms were similar, both indicating a two-factor solution.

Table 36 shows the communalities, factor loadings, and factor score coefficients for Form 1 and Form 2. For both forms, Phase 2 and Phase 3 tests loaded highly on the primary factor and Phase 1 tests loaded highly on the second factor. RGI labeled the factors "Technical" and "Basics" (respectively) to reflect this finding.

Table 36

Communalities, Factor Loadings and Factor Score Coefficients for EM Variables

Test	Communality		Factor Loadings				Factor Score Coefficients			
			Form 1		Form 2		Form 1		Form 2	
	Form 1	Form 2	Fac1[a] Technical	Fac2[b] Basics	Fac1 Technical	Fac2 Basics	Fac1 Technical	Fac2 Basics	Fac1 Technical	Fac2 Basics
Math	.212	.077	.213	.408	.146	.235	-.014	.068	-.000	.022
Safety	.155	.297	.248	.306	.448	.309	.016	.032	.049	.011
Basics	.486	.471	.240	.655	.365	.581	-.080	.225	-.036	.147
DC Circuit	.478	.415	.222	.655	.389	.514	-.084	.225	.026	.089
AC Circuit	.407	.434	.234	.693	.232	.617	-.058	.164	-.045	.157
Inductance	.425	.601	.229	.610	.357	.688	-.067	.184	-.079	.249
Capacitance	.360	.605	.179	.572	.176	.758	-.068	.161	-.169	.338
Comp 1	.437	.550	.201	.630	.245	.700	-.085	.207	-.066	.207
Engineering	.273	.330	.475	.217	.510	.264	.086	-.015	.085	-.009
Generators	.408	.450	.506	.390	.571	.351	.083	.028	.113	.015
Distribution	.385	.314	.444	.433	.457	.325	.047	.059	.068	.003
Motors	.329	.364	.470	.328	.484	.359	.072	.100	.057	.004
Controllers	.366	.405	.462	.390	.575	.273	.058	.040	.129	-.043
Comp 2	.444	.437	.523	.412	.543	.378	.087	.036	.108	.005
Galley	.440	.600	.611	.257	.769	.096	.150	-.042	.367	-.223
Lighting	.445	.402	.641	.187	.571	.275	.180	-.081	.119	-.037
Small Craft	.471	.370	.657	.200	.524	.309	.194	-.081	.073	-.002
Auxilliary	.424	.413	.635	.145	.531	.362	.186	-.093	.113	-.007
Comp 3	.365	.357	.578	.178	.451	.391	.136	-.060	.061	.017
Elect 1	.303	.271	.429	.345	.305	.421	.067	.019	.008	.056
Elect 2	.321	.123	.408	.252	.169	.307	.102	-.018	.002	.036
Elevators	.237	.192	.451	.184	.399	.181	.084	-.022	.066	-.009
Comp 4	.403	.351	.489	.405	.552	.214	.077	.035	.126	-.032

Note. For Form 1, n = 716. For Form 2, n = 175.
[a] Fac1 = Factor 1.
[b] Fac2 = Factor 2.

While the factors appear to have the same underlying factors, we computed congruence coefficients which indicate that the factor patterns are different (Horsuch, 1983, p. 285, Congruence = .21 $p<.05$ for Factor1, and Congruence = .23, $p<.05$ for Factor2).

We sought to develop composite variables which would capture essential elements of the criterion variance and also represent meaningful dimensions

Table 37

Descriptive Statistics for EM Composite Variables

Composite	n	Rel[a]	Mean	Std Dev	Skew	Kurtosis	Min	Max
Form 1								
Sum 1[b]	730	.89	86.851	6.077	-.331	-.359	68.60	99.94
Sum 2[c]	716	.89	87.188	5.786	-.245	-.289	67.62	99.63
FSG	773	N/A	87.805	4.884	.078	-.334	67.10	99.70
FSG2[d]	716	.92	86.974	5.585	-.150	-.500	69.17	99.76
Basics[e]	748	.82	87.383	6.667	-.576	-.204	59.96	100.00
Technical[f]	730	.89	87.035	6.000	-.291	-.433	70.23	99.93
Form 2								
Sum 1	177	.91	86.601	5.813	-.060	-.583	70.89	98.39
Sum 2	178	.91	87.716	5.747	-.139	-.766	73.46	98.94
FSG	187	N/A	87.689	5.006	-.131	.482	67.00	98.40
FSG2	175	.92	87.049	5.369	.014	-.721	73.33	98.59
Basics	182	.85	88.835	6.089	-.368	-.675	71.97	99.47
Technical	177	.87	86.449	5.658	-.003	-.643	73.95	98.90

[a] These are composites based on communality estimates and the procedures described in the text.
[b] Sum1: (Average of all tests with Factor 1 loadings greater than or equal to .30).
[c] Sum2: (Average of all tests with Factor 2 loadings greater than or equal to .30).
[d] FSG2: Final School Grade computed using initial test scores.
[e] Basics: Average score of Phase 1 tests: (Math, Safety, Basics, DC Circuit, AC Circuit, Inductance, Capacitance, Comp 1). Does not include Math Pretest.
[f] Technical: Average score of Phase 2 & 3 tests: (Engineering, Generators, Distribution, Motors, Controllers, Comp 2, Galley, Lighting, Small Craft, Auxilliary, Comp 3, Elect 1, Elect 2, Elevators, Comp 4).

useful to the EM school. Correlations with the empirical factors would illustrate the degree to which the simpler unit-weighted composites could represent the empirically defined factor. Accordingly, we developed a Technical composite (the average of all Phase 2 and Phase 3 tests) to represent Factor 1, and a Basics composite (the average of all Phase 1 tests except Math Pretest) to represent Factor 2. We also created Sum 1 and Sum 2 composite variables from an average of all tests loading .3 or greater on either Factor 1 or Factor 2, respectively. Since the EM school computed the FSG using 75 as the minimum score, RGI calculated its own final grade (FSG2) using initial test scores and

Table 38

Correlations Among EM Composites and Factors

Composite	Factor1	Factor2	Sum1[a]	Sum2[b]	FSG	FSG2[c]	Basics[d]	Technical[e]
Factor 1	—	.16	.87	.68	.79	.79	.48	.90
Factor 2	.17	—	.62	.81	.70	.72	.90	.54
Sum 1	.90	.52	—	.95	.98	.99	.83	.98
Sum 2	.60	.88	.85	—	.96	.97	.92	.91
FSG	.79	.71	.93	.94	—	.99	.87	.96
FSG2	.79	.73	.94	.95	.98	—	.89	.96
Basics	.36	.95	.64	.92	.82	.84	—	.74
Technical	.93	.51	.99	.84	.94	.95	.64	—

Note. Coefficients below the diagonal correspond to Form 1 (n = 716). Coefficients above the diagonal correspond to Form 2 (n = 175).

[a] Sum1: (Average of all tests with Factor 1 loadings greater than or equal to .30).

[b] Sum2: (Average of all tests with Factor 2 loadings greater than or equal to .30).

[c] FSG2: Final School Grade computed using initial test scores.

Basics: Average score of Phase 1 tests: (Math, Safety, Basics, DC Circuit, AC Circuit, Inductance, Capacitance, Comp 1).

[e] Technical: Average score of Phase 2 & 3 tests: (Engineering, Generators, Distribution, Motors, Controllers, Comp 2, Galley, Lighting, Small Craft, Auxilliary, Comp 3, Elect 1, Elect 2, Elevators, Comp 4).

listed both as composite variables. We employed the factor scores (Factor 1 and Factor 2) as additional composites. Table 37 shows the descriptive statistics for each of the composite variables noted above. The sample size varied for the composites depending on the number of tests missing for each case.

Next, we computed Pearson correlation coefficients for the composite variables. Table 38 presents these correlations. Notice that FSG and FSG2 correlated .98 and .99 for Form 1 and Form 2, respectively. This offers no support for using initial test scores in FSG. For both Form 1 and 2, the Technical composite showed the largest correlation with Factor 1 (.93 and .90, respectively), and the Basics composite showed the largest correlation with Factor 2 (.95 and .90, respectively). The Sum1 and Sum2 variables did not

correlate as high with their associated factor scores. Further, Sum1 and Sum2 had higher correlations with opposite factor scores than did the Basics and Technical composites. Finally, for Forms 1 and 2, respectively, FSG correlated .82 and .87 with Basics and .94 and .96 with Technical.

Recommendations. In addition to FSG, use an average of Phase 1 tests.

Electronic Technician Phase 1 (ET1)

Instruction for the Electronic Technician School takes place over the course of two phases. Students first attend Phase 1, located in Orlando, Florida. Upon satisfactory completion of Phase 1, students move on to Phase 2, located in Great Lakes, Michigan. The present section covers the Phase 1 curriculum, which we labeled ET1. The subsequent section addresses the Phase 2 curriculum (labeled ET2).

Description of Variables. The ET school administers the following types of tests to assess student progress: lab quizes, blitzes, homework, knowledge exams, performance exams, and cumulative exams. Because so many of the cases had incomplete data on these tests, we restricted our analyses to the knowledge and performance exams. These were also the only tests included in the FSG. Valid ranges for the test scores vary (the maximum possible score ranges from 5 to 100). Table 39 presents these tests and their corresponding descriptions.

The school requires a minimum passing grade of 63% on all quizzes and exams for graduation. Students who score below 63% receive remediation and a retest. The school allows one retest and assigns students who fail the retest to an Academic Review Board. Students receive a score of 63% when they pass a retest or repeat an area of instruction. However, in the present study, RGI entered all initial test scores into the database.

Sample. The initial sample consisted of 130 students who began training between April and October, 1990. We exluded students who did not take every test from some of the analyses. Consequently, our final sample contained 66 cases.

Results and Discussion. Because the valid range differed among the tests, we converted each test to a scale of 0-100 by transforming them into percent correct scores. Then we computed descriptive statistics for each of the test

Table 39

Descriptions of ET1 Variables

Test	Description (Name - Type of Test)[a]
10401-10409	**Knowledge:** Learning & study skills, math for basic electronics/scientific calculator/graphs/maps, electrical safety & firefighting procedures, magnetic & chemical properties of matter (Basics-K).
29401-29409	**Performance:** Electrical energy, series & parallel DC circuits (DC Circ-P).
20401-20409	**Knowledge:** Electrical energy, series & parallel DC circuits (DC Circ-K).
39401-39409	**Performance:** AC theory, test equipment, capacitance, inductance, transformers (AC Theory-P).
30401-30409	**Knowledge:** AC theory, test equipment, capacitance, inductance, transformers (AC Theory-K).
49401-49409	**Performance:** RLC circuit analysis, tuned circuits & filters, integrators & defferentiators, semiconductor diodes, limiters (AC Circ-P).
40401-40409	**Knowledge:** RLC circuit, tuned circuit/filter, integrator/differentiator, semiconductor diode, limiters (AC Circ K).
50401-50409	**Knowledge:** Clampers, transistors, audio frequency amplifiers, special amplifiers (Trans-K).
60401-60409	**Knowledge:** Electron tube diodes & triodes, solid state power supplies, special semiconductor devices (Power Sup-K).
70401-70409	**Knowledge:** Wave generating circuits: Multivibrators, sawtooth generators, oscillators (Wave Circ-K).
80401-80409	**Knowledge:** Decibels, AM receivers, radio/intermediate frequency amplifiers & mixers, receiver alignment (AM Recvr-K).
90401-90409	**Knowledge:** AM transmitters, radio frequency power amplifiers, amplitude modulation, transceivers, transmission lines and antennas, transmission lines, radio frequency radiation hazards (Xmtr-K).

[a] K: Knowledge, P: Performance.

variables. Table 40 presents these statistics. Because many of the students missed several of the exams, we were not able to conduct a factor analysis for this school. Also, because of the small sample sizes for the AC Theory and Power Sup tests (for each test, $\underline{n}$ = 21), we did not include them in further analyses.

Next, we sought to develop composite variables which would capture essential elements of the criterion variance and also represent meaningful content dimensions useful to the ET school. Table 41 presents Pearson correlation coefficients for the test variables and FSG. These correlations show the pattern of relationships between the individual tests.

Table 40

Descriptive Statistics for ET1 Variables

Variable	n	Mean	Std Dev	Skew	Kurtosis	Min	Max
Basics-K	130	90.092	6.833	-1.148	1.075	66.00	100.00
DC Circ-P	127	93.602	7.814	-1.465	2.266	62.50	100.00
DC Circ-K	128	83.234	11.089	-2.619	15.562	08.00	100.00
AC Theory-P	129	85.969	14.335	-1.475	3.011	30.00	100.00
AC Theory-K	021	79.429	09.532	- .254	- .117	58.00	096.00
AC Circ-P	129	84.961	20.771	-1.408	1.261	20.00	100.00
AC Circ-K	129	79.519	12.494	-1.291	2.381	26.00	098.00
Trans-K	128	74.672	11.568	- .795	1.820	26.00	096.00
Power Sup-K	021	77.714	10.813	- .100	- .545	56.00	096.00
Wave Circ-K	128	70.828	14.232	- .613	.342	26.00	094.00
AM Recvr-K	128	76.109	10.578	- .320	- .514	48.00	096.00
Xmtr-K	067	78.507	09.486	- .499	- .123	54.00	098.00

Table 41

Correlations Among ET1 FSG and Test Variables

Variable	1	2	3	4	5	6	7	8	9	10
1. FSG										
2. Basics-K	.33									
3. DC Circ-P	.28	.21								
4. DC Circ-K	.71	.37	.19							
5. AC Theory-P	.46	.03	.15	.32						
6. AC Circ-P	.21	-.12	-.08	.05	.09					
7. AC Circ-K	.69	.22	.19	.55	.34	.16				
8. Trans-K	.79	.27	.17	.60	.28	.18	.45			
9. Wave Circ-K	.66	.27	.13	.33	.21	.13	.42	.47		
10. AM Recvr-K	.68	-.05	.13	.38	.15	.10	.30	.58	.39	
11. Xmtr-K	.73	.19	.18	.39	.28	-.04	.47	.59	.53	.57

Note. n = 66.

Table 42

Descriptive Statistics for ET1 Composite Variables

Composite	n	Rel[a]	Mean	Std Dev	Skew	Kurtosis	Min	Max
FSG	130		81.212	6.174	.189	- .637	67.50	095.40
FSG2[b]	066		79.927	7.052	- .247	- .318	61.70	095.10
KTest[c]	067		88.130	6.972	- .423	- .166	62.29	095.14
PTest[d]	127		88.130	9.278	- .593	- .521	65.83	100.00
Phase 1[e]	126		88.262	9.278	- .745	.399	66.19	99.50
Phase 2[f]	128		79.870	10.554	- .603	- .265	50.67	97.33
Phase 3[g]	067		76.925	9.126	- .421	- .052	54.00	94.67

[a] These are composites based on communality estimates determined through regression procedures.
[b] FSG2: Final School Grade computed using initial test scores.
[c] KTests: Average of all knowledge test scores.
[d] PTests: Average of all quiz scores.
[e] Phase 1: Average of Basics-K, DC Circ-P, DC Circ-K, and AC Theory-P test scores.
[f] Phase 2: Average of AC Circ-P, AC Circ-K, and Trans-K test scores.
[g] Phase 3: Average of Wave Circ-K, AM Recvr-K, and Xmtr-K test scores.

In order to examine whether test method could explain aspects of school performance, we developed a knowledge test (KTest) composite and a performance test (PTest) composite. Since the ET1 school computes the FSG using 63 as the minimum score, RGI calculated its own final grade (See Appendix F for calculation) using initial test scores and listed both as composite variables. Finally, we developed three more composites based on averages of the test material included in the school's cumulative exams: Phase 1 (Basics-K, DC Circ-P, DC Circ-K, and AC Theory-P), Phase 2 (AC Circ-P, AC Circ-K, and Trans-K), and Phase 3 (Wave Circ-K, AM Recvr-K, and Xmtr-K). Table 42 presents the descriptive statistics for each of the composites mentioned above. For comparison, we placed all the composite variables on a scale of 0-100 by transforming them into percent correct scores. The sample size varied for the composites depending on the number of tests missing in each case.

Table 43

Correlations Among ET1 Composites

Variable	FSG	FSG2	KTests	PTests	Phase 1	Phase 2
1. FSG						
2. FSG2[a]	.95					
3. K Tests[b]	.95	.99				
4. P Tests[c]	.44	.38	.30			
5. Phase 1[d]	.72	.61	.65	.47		
6. Phase 2[e]	.62	.60	.56	.83	.34	
7. Phase 3[f]	.85	.95	.90	.23	.43	.43

Note. n = 66.
[a] FSG2: See Appendix _ for computation.
[b] KTests: Average of all knowledge test scores.
[c] PTests: Average of all performance scores.
[d] Phase 1: Average of Basics-K, DC Circ-P, DC Circ-K, and AC Theory-P test scores.
[e] Phase 2: Average of AC Circ-P, AC Circ-K, and Trans-K test scores.
[f] Phase 3: Average of Wave Circ-K, AM Recvr-K, and Xmtr-K test scores.

Then, we computed Pearson correlation coefficients for the composites. Table 43 presents the composite variable correlations. Since FSG and FSG2 correlate .95, this offers little support for using initial test scores to compute FSG.

In reviewing the results with the phase variables, we find that Phase 1 correlates moderately (.47 to .72) with FSG and the knowledge and performance composites. Phase 2 correlates highest (.83) with the performance composite, and Phase 3 correlates very highly (.85 and .90, respectively) with FSG and the knowledge composite.

Finally, FSG correlates .95 with KTests and .44 with PTests. These findings support using FSG as an indicator of for knowledge tests but suggest using a separate indicator for performance tests.

Recommendations. In addition to FSG, use PTests (an average of DC Circ-P, AC Theory-P, and AC Circ-P).

Electronic Technician Phase 2 (ET2)

Instruction for the Electronic Technician School takes place over the course of two phases. Students first attend Phase 1, located in Orlando, Florida. Upon satisfactory completion of Phase 1, students move on to Phase 2, located in Great Lakes, Michigan. The preceeding section (labeled ET1) covers the Phase 1 curriculum. This section, ET2, addresses the Phase 2 curriculum.

Description of Variables. The ET school administers the following types of tests to assess student progress: blitzes, homework, knowledge exams, and performance exams. Because so many of the cases had incomplete data on these tests, we restricted our analyses to the knowledge and performance exams. These were also the only tests included in the FSG. All tests have a valid range of 0-100. Table 44 presents these tests and their corresponding descriptions.

The school divided the course into training areas, also shown in Table 44. On March 31, 1991, the school incorporated a new area (AC Primary Power Distribution and Supplies) into its curriculum. Students entering the ET2 course after the addition of the new area received less time per training area.

The school requires a minimum passing grade of 63% on all quizzes and exams for graduation. Students who score below 63% receive remediation and a retest. The school allows one retest and assigns students who fail the retest to an Academic Review Board. Students receive a score of 63% when they pass a retest or repeat an area of instruction. However, in the present study, RGI entered all initial test scores into the database.

Sample. The entire sample consisted of 114 students who began training between October 1990 and December 1991. We excluded students who did not take every test from some of the analyses. Consequently, our final sample contained 83 cases.

Table 44

Descriptions of ET2 Variables

Area	Test	Description (Name - Type of Test)[a]
1	501	**Knowledge:** FM fundamentals and DC circuit analysis, narrow band frequency modulator, receiver functional operation, biased semiconductor diode PN junction, basic amplifier (FM/DC-K).
2	502	**Knowledge:** Single sideband receiver (SSB) functional operations and receiver fundamentals, receiver front end circuits, intermediate frequency amplifiers, demodulator, audio amps/reproduction devices (SSB Recvr-K).
2	602	**Performance:** Single sideband receiver troubleshooting (SSB Recvr-P).
3	503	**Knowledge:** SSB transmit functional circuits, oscillators, SSB modulation, first intermediate frequency amps, four diode/high frequency balanced mixer & RF amplifier (SSB Xmtr-K).
3	603	**Performance:** Single sideband transmitter troubleshooting (SSB Xmtr-P).
11	511	**Knowledge:** R-1051B/URR high frequency receiver functional block diagrams, AC/DC distribution & antenna/amplifier/transistor/synthesizer/receiver mode selector, EF/AF amplifier (AN/WRC-K).
11	611	**Performance:** AN/WRC - 1B receiver, troubleshooting principles for R-1051B/URR (AN/WRC-P).
12	512	**Knowledge:** AN/URT-24 operations, high frequency transmitter T-827 chassis & main frame circuit analysis, FSK tone generator, transmit mode selector/IF, AF & RF amp, AM-3007/URT, CU-937/UR (AN/URT-K).
12	612	**Performance:** AN/URT - 24 operations and troubleshooting (AN/URT-P).

On March 31, 1991, the school added a new course area (Primary Power Distribution and Supplies) and defined it as Area 13. The school renamed previous Areas 13 and 14 as 14 and 15. Form 1 covers students entering the school before March 31, 1991. Form 2 addresses students entering the school after this date.

13	513	**Knowledge:** **Form 1:** WSC-3 UHF transceiver, functional operation, power supply & distribution, frequency standard & synthesizer operation, transmitter function/signal flow/control operation/distribution/interface/BITE operation analysis, recvr operation/signal flow/BITE operation, recvr & xmtr paper troubleshooting (UHF-K). **Form 2:** URT-23/URA-38 operation, primary power circuit analysis (URT/URA-K).
13	613	**Performance:** **Form 1:** WSC-3 UHF transceiver operations & troubleshooting (UHF-P). **Form 2:** URT-23/URA-38 operations & troubleshooting (URT/URA-P).
14	514	**Knowledge:** **Form 1:** Telecommunication systems, communications planning, blueprints, remote units, teletype principles & patch panels, URA-17 teletype converter circuit analysis, CV-2460 & UCC-1 multiplexer converter & keyer function circuit analysis (Telecom-K). **Form 2:** WSC-3 UHF transceiver, functional operation, power supply & distribution, frequency standard & synthesizer operation, transmitter function/signal flow/control operation/distribution/interface/BITE operation analysis, recvr operation/signal flow/BITE operation, recvr & xmtr paper troubleshooting (UHF-K).
14	614	**Performance:** **Form 1:** Telecommunication systems operations & troubleshooting (Telecom-P). **Form 2:** WSC-3 UHF transceiver operations & troubleshooting (UHF-P).
15	515	**(Form 2 only) Knowledge:** Telecommunication systems, communications planning, blueprints, remote units, teletype principles & patch panels, URA-17 teletype converter circuit analysis, CV-2460 & UCC-1 multiplexer converter & keyer function circuit analysis (Telecom-K).
15	615	**(Form 2 only) Performance:** Telecommunication systems operations & troubleshooting (Telecom-P).

[a] K: Knowledge, P: Performance.

Table 44 (continued)

Area	Test	Description (Name - Type of Test)[a]
21	521	**Knowledge:** Intro to radar & AN/SPS-10. radar principles. intro to systems vacuum tube principles. microwave transmitting tubes (Radar-K).
22	522	**Knowledge:** Vacuum tube to point ground. MPG microwave devices & tubes. radar frequency system (MPG-K).
22	622	**Performance:** Vacuum tube to point ground & MPG microwave devices troubleshooting labs (MPG-P).
23	523	**Knowledge:** Intro to AN/SPS receivers. IF strip. detect/video. interference elimination circuits. AFC synchro/servos. antenna systems (SPS-K).
23	623	**Performance:** Receiver & systems labs (SPS-P).
24	524	**Knowledge:** Planned position indicator display. intro to AN/SPA-25 & special circuits. AN/SPA timing section. power supply. operation & timing circuits (SPA1-K).
24	624	**Performance:** AN/SPA-25 troubleshooting (SPA1-P).
25	525	**Knowledge:** AN/SPA-25 azimmuth resolver & bearing cursor. video cursor sweep switch. sweep generators/yoke drivers/ range strobe generator block. range ring generator. vidio section (SPA2-K).
25	625	**Performance:** AN/SPA-25 sweep & brightening troubleshooting (SPA2-P).

[a] K: Knowledge, P: Performance.

Results and Discussion. As noted above, on March 31, 1991, the school added a new training area and reduced the time devoted to each training area. Because of these changes, RGI separated the students based upon whether they entered the school before or after the changes, and we analyzed the two forms separately. Form 1 contains students who entered the course before March 31, 1991 (n = 70). Form 2 contains students taking the course after this date (n = 44). Form 1 included 16 cases with missing data. RGI excluded these cases from some of the analyses, resulting in a final sample of 54 cases for Form 1. Form 2 included 15 cases with missing data. Likewise, we excluded these cases from some of the analyses, resulting in a final sample size of 29 cases for Form 2.

RGI computed descriptive statistics for each of the test variables. Table 45 presents these statistics. Because Form 2 contained zero cases for four of the variables (URT/URA-K, URT/URA-P, UHF-K, and UHF-P), we did not include these tests in the analyses. Also, because many of the students missed several of the exams, we were not able to conduct a factor analysis for this school.

Next, we sought to develop composite variables which would capture essential elements of the criterion variance and also represent meaningful content dimensions useful to the ET school. In order to examine whether test method could explain aspects of school performance, we developed a knowledge test (KTests) composite and a performance test (PTests) composite. Since the ET1 school computes the FSG using 63 as the minimum score, RGI calculated its own final grade (FSG2) using initial test scores. We used the school's weighting scheme to compute FSG2: (average of all knowledge tests * .7) + (average of all performance tests * .3). We listed both FSG and FSG2 as composite variables. Table 46 presents the descriptive statistics for each of the composites mentioned above. We placed all the composite variables on a scale of 0-100 to compare them

Table 45

Descriptive Statistics for ET2 Variables

Variable	n	Mean	Std Dev	Skew	Kurtosis	Min	Max
Form 1:							
FM/DC-K	69	78.252	12.559	-.872	1.749	33.30	100.00
SSB Recvr-K	69	77.583	15.155	-1.188	1.501	23.30	96.70
SSB Recvr-P	69	87.825	16.655	-2.137	4.850	22.00	100.00
SSB Xmtr-K	65	85.640	8.541	-.565	-.137	63.30	100.00
SSB Xmtr-P	65	97.308	19.585	-3.161	9.382	12.00	100.00
AN/WRC-K	64	80.627	12.072	-1.022	.429	50.00	96.70
AN/WRC-P	64	74.828	31.109	-1.119	-.455	14.00	100.00
AN/URT-K	63	84.290	9.304	-.707	.412	56.70	100.00
AN/URT-P	63	87.746	16.661	-3.107	11.381	7.00	100.00
UHF-K	61	81.639	10.122	-.908	1.937	43.30	100.00
UHF-P	61	84.410	23.207	-1.844	2.489	15.00	100.00
Telecom-K	61	77.872	9.968	-1.079	2.161	40.00	93.30
Telecom-P	61	84.769	22.569	-2.252	4.578	10.00	100.00
Radar-K	59	83.344	9.087	-.878	1.342	53.30	100.00
MPG-K	59	74.244	11.888	-.462	-.832	46.70	93.30
MPG-P	59	79.669	24.120	-1.280	.181	24.00	100.00
SPS-K	58	73.102	12.473	-.340	.094	40.00	100.00
SPS-P	58	86.248	19.761	-2.944	9.036	3.00	100.00
SPA1-K	57	76.723	11.171	-.389	-.001	50.00	100.00
SPA1-P	56	81.259	14.139	-2.301	8.830	13.00	98.00
SPA2-K	55	80.855	10.591	-.427	.453	50.00	100.00
SPA2-P	55	79.727	19.496	-2.332	6.222	5.00	98.50
Form 2:							
FM/DC-K	44	79.777	11.689	-.761	.478	50.00	100.00
SSB Recvr-K	43	78.130	15.964	-1.217	1.517	30.00	96.70
SSB Recvr-P	43	91.698	14.342	-2.252	4.155	47.00	100.00
SSB Xmtr-K	43	83.723	9.121	-.054	-.912	66.70	100.00
SSB Xmtr-P	43	95.488	10.573	-4.377	21.729	38.00	100.00
AN/WRC-K	42	81.824	11.338	-.692	.018	53.30	100.00
AN/WRC-P	42	82.381	27.048	-2.096	2.958	3.00	100.00
AN/URT-K	42	85.871	9.304	-.431	-.580	66.70	100.00
AN/URT-P	42	89.952	11.941	-1.942	4.279	45.00	100.00
Telecom-K	31	83.226	12.282	-.758	-.215	56.00	100.00
Telecom-P	31	92.103	14.722	-2.887	8.719	35.00	100.00
Radar-K	40	81.737	9.426	-.711	.023	60.00	96.00
MPG-K	40	78.245	11.478	-.244	-.933	53.30	96.70
MPG-P	40	86.030	19.936	-1.785	1.861	35.00	100.00
SPS-K	40	78.000	9.885	.032	-1.178	60.00	93.30
SPS-P	40	75.000	32.264	-1.200	-.149	3.50	100.00
SPA1-K	40	77.917	13.236	-1.117	1.354	36.70	96.70
SPA1-P	40	78.037	20.798	-1.527	1.317	25.00	99.50
SPA2-K	39	81.105	9.088	.091	-.740	63.30	96.70
SPA2-P	39	83.979	14.690	-2.016	4.862	30.00	100.00

Table 46

Descriptive Statistics for FT2 Composite Variables

Composite	n	Rel[a]	Mean	Std Dev	Skew	Kurtosis	Min	Max
Form 1:								
FSG	70	N/A	80.594	5.334	.196	- .430	68.70	93.80
FSG2[b]	54	.91	82.329	5.668	- .315	- .145	68.30	93.70
KTest[c]	54	.91	81.005	5.882	- .106	- .199	68.93	92.12
PTest[d]	55	.72	85.266	8.907	-1.123	1.149	57.70	97.65
Form 2:								
FSG	44	N/A	81.891	6.831	.120	-1.066	70.30	94.70
FSG2	29	.96	81.650	7.296	- .245	1.355	68.10	95.50
KTest	29	.96	79.961	7.476	- .368	- .511	64.00	92.91
PTest	29	.87	85.590	9.437	- .583	- .386	62.50	98.17

[a] These are composites based on communality estimates determined through regression procedures.
[b] FSG2: Final School Grade computed using the initial test scores.
[c] KTests: Average of all knowledge test scores.
[d] PTests: Average of all performance test scores.

more readily. The sample size varied for the composites depending on the number of tests missing in each case.

Finally, we computed Pearson correlation coefficients for the composites. Table 47 presents the composite variable correlations. For Form 2, FSG and FSG2 correlate low (.64), considering that they should measure the same thing. For Form 1, the correlation between FSG and FSG2 is somewhat higher (.87), although this form contains a smaller sample size. These findings support using initial test scores to compute a final school grade (FSG2).

In both cases, KTests correlates highly with FSG2 (.90 for Form 1, .95 for Form 2). PTests correlates less strongly (.74 and .82, respectively). Finally, the correlation between KTests and PTests is .36 for Form 1 and .60 for Form 2. Considering that the sample with the larger n (Form 1) shows a lower correlation, these findings suggest that the composites are relatively independent.

Table 47

Correlations Among ET2 Composites

Variable	FSG	FSG2[a]	KTests[b]	PTests[c]
FSG	—	.87	.88	.62
FSG2	.64	—	.95	.82
K Tests	.61	.90	—	.60
P Tests	.41	.74	.36	—

Note. Coefficients below the diagonal correspond to Form 1 (n = 54). Coefficients above the diagonal correspond to Form 2 (n = 29).

[a] FSG2: Final School Grade computed using the initial test scores.

[b] KTests: Average of all knowledge test scores.

[c] PTests: Average of all performance test scores.

Recommendations. In addition to FSG2, use PTests (an average of all performance tests).

Engineman (EN)

Description of Variables. Before October 1, 1990, all EN students took Propulsion Engineering (PE) Basics as a prerequisite course. Civilian personnel taught PE, and military personnel taught EN. As of October 1, 1990, the EN school incorporated the PE school into the EN course curriculum increasing the length of the school from 9 to 11 1/2 weeks. The school restructured and reordered the presentation of the previous course material and integrated it with the new PE Basics material. However, course content did not change. Following this merger, teaching responsibilities for the PE course shifted from civilian to military personnel.

In May of 1991 (the school could not provide a more specific date), the school prepiloted a revised course curriculum that incorporated several new lessons. At the time of this revision the school also separated the curriculum into 3 distinct phases. Phase I covers the first four weeks of training, Phase II covers weeks five through eight, and Phase III covers the last three and a half weeks. The school administers a comprehensive phase exam following each phase. The school also phased out quizzes during the May 1991 prepilot of the new three-phase curriculum. The school began implementing this new curriculum in May of 1991 and finalized it in October of 1991.

The school requires a score of 75% or higher to pass each quiz and exam. Examinees who fail a quiz or exam participate in remediation and retesting. The instructor assigns the minimum passing score to those students who pass the retest, and the school uses that minimum score in calculating the final school grade (FSG). All students who fail the retest appear before the Academic Review Board. RGI entered only the initial test scores for each examinee. However, the school assigns a score of 75 for all successful retests.

As a result of these revisions, there are three test forms for the EN database: Test Form: A=Through September 30, 1990; B=October 1, 1990 through May 1991; and C=After May 1991. Table 49 presents the EN test numbers and a description of the tests followed by the name in parentheses.

To compute FSG, the EN school used the following formulas during the various Phases. For Phase A (Form A), the school weighted quizzes 3.33% (6 quizzes x 3.33% = 20%), exams 10% (5 exams x 10% = 50%), and comprehensive exams 15% (2 comprehensive exams x 15% = 30%). For Phase B (Form B), the school weighted quizzes 1.75% (8 quizzes x 1.75% = 14%), exams 8.0% (7 exams x 8.0% = 56%), and comprehensive exams 15% (2 comprehensive exams x 15% = 30%). For phase C the school weighted exams 6.875% (8 exams x 6.875% = 55%) and comprehensive exams 15% (3 comprehensive exams x 15% = 45%).

Sample. The Form A sample consisted of 137 students, the Form B sample consisted of 423 students, and the Form C sample consisted of 300 students.

Results and Discussion. We began by conducting an analysis to determine if there were differences among the three groups due to changes in the school curriculum. We conducted a multivariate analysis of variance (MANOVA) to test the covariance matrices of five test scores having similar content across the three groups. A homogeneity of covariances revealed that the three groups had significantly different covariance matrices ($F=6.688$, $p<.001$). The test means also differed significantly ($F=17.72$, $p<.001$). We then conducted pairwise comparisons and found significant differences in the covariance matrices (Groups A and B, $F=6.525$, $p<.001$; Groups A and C, $F=3.644$, $p<.001$; Groups B and C,

Table 48

Descriptions of EN Variables

Week	Test No.	Description (Name-Type of Test)[a]
		Test Form A
1	013	**Quiz:** Introduction to diesel engines, diesel engine construction, diesel engine air intake systems, diesel engine exhaust systems. (Diesel Engines-Q)
1	016	**Exam:** Introduction to diesel engines, diesel engine construction, diesel engine air intake systems, diesel engine exhaust systems. (Diesel Engines-K)
2	023	**Quiz:** Diesel engine fuel systems, diesel engine lube oil systems, diesel engine cooling water systems. (Diesel Fuel Sys.-Q)
2	026	**Exam:** Diesel engine fuel systems, diesel engine lube oil systems, diesel engine cooling water systems. (Diesel Fuel Sys.-K)
3	033	**Quiz:** Diesel engine air starting systems, diesel engine control systems, intro. to GM 6-71 series diesel engine. (Air Start Sys.-Q)
3	036	**Exam:** Diesel engine air starting systems, diesel engine control systems, intro. to GM 6-71 series diesel engine. (Air Start Sys.-K)
5	053	**Quiz:** Clutches, main reduction gear, main reduction gear lube oil system, main propulsion shafting system, controllable pitch propeller system, electro-hydraulic steering system. (Clutches-Q)
5	056	**Comprehensive Exam 1:** Clutches, main reduction gear, main reduction gear lube oil system, main propulsion shafting system, controllable pitch propeller system, electro-hydraulic steering system, all material covered in weeks 1 through 5. (Comprehensive Test1)
6	063	**Quiz:** Intro. to shipboard electrical circuits, 60Hz electrical distribution system, interior communications (IC) alarm systems, small craft operations, small craft electrical distribution system, small craft propulsion engine hydraulic starting system, small craft steering systems, small craft propulsion engine transmissions, small craft ramp hoisting system. (Ship Elec.-Q)
6	066	**Exam:** Intro. to shipboard electrical circuits, 60Hz electrical distribution system, interior communications (IC) alarm systems, small craft operations, small craft electrical distribution system, small craft propulsion engine hydraulic starting system, small craft steering systems, small craft propulsion engine transmissions, small craft ramp hoisting system. (Ship Elec.-K)
7	073	**Quiz:** Evaporators (distilling plants), auxiliary boilers, air conditioning and refrigeration plants, compressed air systems, shipboard drainage systems, shipboard fire fighting systems, fuel systems. (Shpbd. Fire Fight-Q)
7	076	**Exam:** Evaporators (distilling plants), auxiliary boilers, air conditioning and refrigeration plants, compressed air systems, shipboard drainage systems, shipboard fire fighting systems, fuel systems. (Shpbd. Fire Fight-K)
9	800	**Comprehensive Exam 2:** Shipboard auxiliary equipment, propulsion plant operations, small craft operations, all information covered in weeks 6 through 9. (Comprehensive Test2)

[a]Key to type of test: K-Knowledge, Q-Quiz

Table 45 (Continued)

Week	Test No.	Description (Name-Type of Test)[a]
		Test Form B
1	013	**Quiz:** Command/dept./watch organization, ships maintenance and material management (3-M) system, equipment tag-out procedures, engineering fundamentals, personnel qualification standards (PQS) program, engineering operational sequencing system (EOSS). (Eng. Fundmtls.-Q)
1	016	**Exam:** Command/dept./watch organization, ships maintenance and material management (3-M) system, equipment tag-out procedures, engineering fundamentals, personnel qualification standards (PQS) program, engineering operational sequencing system (EOSS). (Eng. Fundmtls.-K)
2	023	**Quiz:** Technical manuals, common hand tools, precision measuring instruments, metal fasteners, pipe, tubing and fittings, packing, gaskets and insulation, valves (globe, gate butterfly, ball, plug cock, needle). (Tech. Manual-Q)
2	026	**Exam:** Technical manuals, common hand tools, precision measuring instruments, metal fasteners, pipe, tubing and fittings, packing, gaskets and insulation, valves (globe, gate butterfly, ball, plug cock, needle). (Tech. Manual-K)
3	033	**Quiz:** Heat exchangers, lubricants, bearings, gears, couplings, pumps, intro. to shipboard electrical circuits, interior communication alarms system 60Hz electrical distribution system, shipboard internal communication devices. (Ship Elec./Comm-Q)
3	036	**Exam:** Heat exchangers, lubricants, bearings, gears, couplings, pumps, intro. to shipboard electrical circuits, interior communication alarms system 60Hz electrical distribution system, shipboard internal communication devices. (Ship Elec./Comm-K)
4	043	**Quiz:** Compressed air systems, auxiliary machinery cooling water system, potable water system, main drain system, waste water/oily waste systems, fire fighting equipment, shipboard firemain system, single agent fire fighting system, halon 1301 fire fighting system, cold iron watchstation indoctrination. (Shpbd. Fire Fight-Q)
4	046	**Exam:** Compressed air systems, auxiliary machinery cooling water system, potable water system, main drain system, waste water/oily waste systems, fire fighting equipment, shipboard firemain system, single agent fire fighting system, halon 1301 fire fighting system, cold iron watchstation indoctrination. (Shpbd. Fire Fight-K)
5	053	**Quiz:** Diesel engine construction, diesel engine air intake systems, diesel engine exhaust systems, diesel engine cooling water systems. (Diesel Engines-Q)
5	056	**Comprehensive Exam 1:** Diesel engine construction, diesel engine air intake systems, diesel engine exhaust systems, diesel engine cooling water systems, all material covered in weeks 1 through 5. (Comprehensive Test1)
7	073	**Quiz:** Diesel engine lube oil systems, diesel engine fuel systems (external systems), diesel engine fuel systems (injection systems), diesel engine control systems, Diesel engine air starting systems, lube oil fill, transfer and purification system, fuel oil fill, transfer and purification, stripping and ballast systems. (Fuel/Start Sys.-Q)
7	076	**Exam:** Diesel engine lube oil systems, diesel engine fuel systems (external systems), diesel engine fuel systems (injection systems), diesel engine control systems, Diesel engine air starting systems, lube oil fill, transfer and purification system, fuel oil, purification, transfer, stripping and ballast systems. (Fuel/Start Sys.-K)
8	083	**Quiz:** Intro. to diesel engine maintenance (troubleshooting, preparation for overhaul, disassembly, precision measuring, reassembly). (Engine Maint.T/S-Q)
8	086	**Exam:** Intro. to diesel engine maintenance (troubleshooting, preparation for overhaul, disassembly, precision measuring, reassembly). (Engine Maint.T/S-K)
9	093	**Quiz:** Clutches, main reduction gears, main reduction gear lube oil system, pain propulsion shafting system, basic hydraulics. (Clutches-Q)
9	096	**Exam:** Clutches, main reduction gears, main reduction gear lube oil system, main propulsion shafting system, basic hydraulics. (Clutches-K)

[a]Key to Type of Test: K-Knowledge, Q-Quiz

Table 48 (Continued)

Week	Test No.	Description (Name-Type of Test)[a]
11	100	**Comprehensive Exam 3:** Auxiliary equipment, evaporators (distilling plants), auxiliary boilers, air conditioning and refrigeration, small boat electrical distribution system, small boat hydraulic starting system, small boat steering system, small boat transmissions, small boat bow ramp hoisting systems, small boat operations, propulsion plant operations, all material covered in weeks 6 through 11 1/2. (Comprehensive Test2)
		Test Form C
1	016	**Exam:** Command/dept./watch organization, intro. to engineering programs, shipboard safety programs, electrical safety program, hearing conservation program, heat stress program, hazardous material program, environmental protection, ships maintenance and material management (3-M) system, equipment tag-out procedures, engineering fundamentals, personnel qualification standards (PQS) program, engineering operational sequencing system (EOSS). (Eng. Fundmtls.-K)
2	026	**Exam:** Technical manuals, common hand tools, precision measuring instruments, metal fasteners, pipe tubing and fittings, packing, gaskets and insulation, valves (globe, gate butterfly, ball, plug cock, needle). (Tech. Manual-K)
3	036	**Exam:** Heat exchangers, lubricants, bearings, gears, couplings, pumps, intro. to shipboard electrical circuits, interior communication alarms system, 60Hz electrical distribution system, shipboard internal communication devices. (Ship Elec./Comm-K)
4	046	**Comprehensive Exam 1:** Compressed air system, auxiliary machinery cooling water system, potable water system, main drain system, waste water/oily waste systems, fire fighting equipment, shipboard firemain system, single agent fire fighting system, halon 1301 fire fighting system, cold iron watchstation indoctrination, all material covered in weeks 1 through 4. (Comprehensive Test1)
5	056	**Exam:** Diesel engine construction, diesel engine air intake systems, diesel engine exhaust systems, diesel engine cooling water systems. (Diesel Engines-K)
6	066	**Exam:** Diesel engine lube oil systems, diesel engine fuel systems (external systems), diesel engine fuel systems (injection systems), diesel engine control systems. (Fuel/Start Sys.-K)
7	076	**Exam:** Diesel engine air starting systems, surface ship noise awareness program, lube oil quality management program, lube oil fill, transfer and purification system, fuel oil fill, transfer and purification, stripping and ballast systems. (Air Start Sys-K)
8	086	**Comprehensive Exam 2:** Intro. to diesel engine maintenance (troubleshooting, preparation for overhaul, disassembly, precision measuring, reassembly), all material covered in weeks 5 through 8. (Comprehensive Test2)
9	096	**Exam:** Clutches, main reduction gears, main reduction gear lube oil system, main propulsion shafting system, basic hydraulics. (Clutches - K)
10	106	**Exam:** Shipboard auxiliary equipment, evaporators (distilling plants), auxiliary boilers, air conditioning and refrigeration, small boat electrical distribution system, small boat hydraulic starting system, small boat steering system, small boat transmission system, small boat bow ramp hoisting systems, small boat operations. (Ship Aux.Equip/Evaps-K)
11	116	**Exam/Comprehensive Exam 3:** Propulsion plant operation and all material covered in weeks 9 through 11 1/2. (Comprehensive Test3)

[a]Key to Type of Test: K-Knowledge, Q-Quiz

F=8.410, p<.001) and the means (Groups A and B, F=9.382, p<.001; Groups A and C, F=13.41, p<.001; Groups B and C, F=29.328, p<.001) for all pairwise comparisons.

To test whether ability accounted for these differences between the three groups, we conducted a multivariate analysis of covariance (MANCOVA) using the students' pre-enlistment ASVAB scores as covariates. After partialling out the variance due to ASVAB scores, the test for homogeneity of covariance matrices revealed different matrices for the three groups (F=1.886, p<.001). The means also differed across the three groups after accounting for variance due to the ASVAB scores (F=16.012, p<.001). We then conducted pairwise comparisons and found significant differences in the covariance matrices (Groups A and B, F=1.821, p<.001; Groups A and C, F=1.679, p<.001; Groups B and C, F=2.029, p<.001) and the means (Groups A and B, F=10.349, p<.001; Groups A and C, F=11.267, p<.001; Groups B and C, F=24.377, p<.001) for all pairwise comparisons. These results suggest that the no d differences among the three groups are due to something other than differences in ability, and they indicate that the three samples come from three distinct populations.

To further evaluate the conclusion of differences among groups, we computed effect sizes (ES) as measures of the practical significance of the differences between the adjusted means across groups. Cohen and Cohen (1977) state that .2 represents a small ES, .5 is medium, and .8 is large. For the total of 15 comparisons (5 variables x 3 pairwise comparisons), we found 3 ESs within the .00 and .19 range, 8 ESs within the .20 and .49 range, and 4 ESs within the .50 and .79 range. These results show that 73% of the ESs fall below a value of .50. Thus, while the MANOVA tests indicate that the groups differ from one another in terms of statistical significance, the ESs suggest small magnitudes of differences, in terms of practical significance.

We present the results for each of the three forms separately. A discussion following the results of the final form, however, includes all three forms.

Table 49 presents the descriptive statistics for the set of variables used in the analysis of Form A. We excluded quizzes from the factor analysis because there were no quizzes in Form C and, for a comparison, we wanted a uniform set of variables across forms. We conducted a factor analysis on the set of knowledge and comprehensive tests. The scree test and factor loadings indicated a one-factor solution.

Table 50 shows the communalities, factor loadings, and factor score coefficients. All tests loaded highly on the factor, with factor loadings ranging from .55 to .80. We sought to develop composite variables which would capture essential elements of the criterion variance and also represent

Table 49

Descriptive Statistics for EN Variables - Form A

Variable	n	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
Diesel Engines-Q	143	87.860	10.555	-1.445	2.755	40.00	100.00
Diesel Engines-K	143	84.322	10.125	-0.852	0.915	44.00	100.00
Diesel Fuel Sys.-Q	142	87.972	9.664	-0.861	0.810	56.00	100.00
Diesel Fuel Sys.-K	142	83.451	9.726	-0.899	1.108	52.00	100.00
Air Start Sys.-Q	140	89.286	8.104	-0.732	0.115	64.00	100.00
Air Start Sys.-K	140	83.471	10.511	-0.606	0.117	50.00	100.00
Clutches-Q	140	86.371	11.231	-0.817	0.226	52.00	100.00
Comprehensive Test1	140	82.836	9.078	-0.088	0.645	62.00	100.00
Ship Elec.-Q	138	91.681	8.372	-1.168	1.038	64.00	100.00
Ship Elec.-K	138	88.261	7.777	-0.627	0.044	62.00	100.00
Shpbd Fire Fight.-Q	138	87.594	9.825	-1.336	3.025	44.00	100.00
Shpbd Fire Fight.-K	138	87.000	8.354	-0.540	-0.066	60.00	100.00
Comprehensive Test2	137	81.584	8.334	-0.068	-0.511	60.00	100.00

Table 50

Communalities, Factor Loadings and Factor Score Coefficients for EN Variables - Form A

Variable	Communality	Factor Loadings	Factor Score Coefficients
Diesel Engines-K	.434	.690	.158
Diesel Fuel Sys.-K	.487	.734	.194
Air Start Sys.-K	.293	.558	.103
Comprehensive Test1	.475	.710	.172
Ship Elec.-K	.480	.723	.171
Shpbd Fire Fight.-K	.421	.673	.149
Comprehensive Test2	.569	.808	.278

Note. n = 137

meaningful content dimensions useful to the EN school. We computed composite variables based on the two phases in the curriculum. Phase 1 included all tests before comprehensive test and including comprehensive test 1. Phase 2 included all tests before comprehensive test 2 and including comprehensive test 2. We also computed a composite variable based on all of the quizzes. And finally, because the EN school computed the FSG using a 75 as the minimum score, we calculated our own Final School Grade (FSG2) using the initial test scores, and listed both as composite variables. Table 51 presents the descriptive statistics for the composite variables.

Next, we computed Pearson correlation coefficients for the composite variables. Table 52 presents the composite variable intercorrelations. Because FSG and FSG2 correlate .97, this offers no support for using initial test scores to compute FSG.

FSG correlates highest (.97) with Factor 1, followed closely by Phase 2 (.94) and Phase 1 (.93). Finally, Phase 1 and Phase 2 correlate .92 and .90 with FSG, respectively. This supports using FSG as an indicator of Factor 1.

Table 51

Descriptive Statistics for EN Composite Variables - Form A

Composite	n	Rel[a]	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
FSG[b]	143	N/A	85.554	5.686	0.031	-0.458	67.10	97.90
FSG2[c]	137	.892	85.927	6.182	-0.082	-1.026	73.14	97.79
Phase 1[e]	140	.777	83.627	7.480	-0.160	-0.853	67.75	98.00
Phase 2[f]	137	.766	85.647	6.691	-0.063	-0.981	72.67	99.00
Quizzes[g]	137	.682	88.603	5.912	-0.300	-0.816	74.00	100.00

[a]These are composites based on communality estimates and the procedures described in the text.
[b]FSG: Final School Grade computed by the EN school.
[c]FSG2: Final School Grade computed using initial test scores.
[d]Phase1: Average of all tests up to and including Comprehensive Test1.
[e]Phase2: Average of all tests up to and including Comprehensive Test2.
[f]Quizzes: Average of all Quizzes.

Table 52

Correlations Among EN Composites and Factors - Form A

Composite	Factor1[a]	FSG[b]	FSG2[c]	Phase 1[d]	Phase 2[e]
FSG	.97				
FSG2	.97	.97			
Phase 1	.93	.92	.96		
Phase 2	.94	.90	.89	.77	
Quizzes[f]	.76	.83	.87	.77	.68

[a]These are composites based on communality estimates and the procedures described in the text.
[b]FSG: Final School Grade computed by the EN school.
[c]FSG2: Final School Grade computed using initial scores.
[d]Phase1: Average of all tests up to and including Comprehensive Test1.
[e]Phase2: Average of all tests up to and including Comprehensive Test2.
[f]Quizzes: Average of all Quizzes.

Results Form B. Table 53 presents the descriptive statistics for the set of variables used in the analysis of Form B. We excluded quizzes from the factor analysis because there were no quizzes in Form C and, for a comparison, we wanted a uniform set of variables across forms. We conducted a factor analysis on the set of knowledge and comprehensive tests. The scree test and factor loadings indicated a one-factor solution.

Table 54 shows the communalities, factor loadings, and factor score coefficients. All tests loaded highly on the factor, with factor loadings ranging from .57 to .77.

We sought to develop composite variables which would capture essential elements of the criterion variance and also represent meaningful content dimensions useful to the EN school. We computed composite variables based on the two phases in the curriculum. Phase 1 included tests before comprehensive test 1 and including comprehensive test 1. Phase 2 consisted of all tests before comprehensive test 2 and including comprehensive test 2. We also computed a composite variable based on the Propulsion Engineering (PE) courses and a composite based on all of the quizzes. And finally, because the EN school computed the FSG using a 75 as the minimum score, we calculated our own Final School Grade (FSG2) using the initial test scores, and listed both as composite variables. Table 55 presents the descriptive statistics for the composite variables.

Table 53

Descriptive Statistics for EN Variables - Form B

Variable	n	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
Eng. Fundmtls-Q	469	85.962	10.284	-1.022	2.528	24.00	100.00
Eng. Fundmtls-K	467	82.107	10.011	-0.574	-0.085	50.00	100.00
Tech. Manual-Q	459	82.885	11.376	-0.826	0.824	36.00	100.00
Tech. Manual-K	457	87.379	8.064	-0.678	0.461	54.00	100.00
Ship Elec./Comm.-Q	452	89.212	8.680	-1.046	0.768	56.00	100.00
Ship Elec./Comm.-K	453	83.907	9.548	-0.683	0.836	44.00	100.00
Shpbd. Fire Fight-Q	448	83.679	10.580	-0.650	0.347	48.00	100.00
Shpbd. Fire Fight-K	448	79.415	11.243	-1.151	2.452	22.00	100.00
Diesel Engines-Q	440	86.327	10.028	-0.962	0.955	48.00	100.00
Comprehensive Test1	438	84.795	6.657	-0.240	-0.216	64.00	100.00
Fuel/Start.Sys.-Q	437	85.876	11.283	-0.471	1.395	40.00	100.00
Fuel/Start.Sys.-K	436	80.128	10.030	-0.471	-0.205	48.00	100.00
Eng. Maint. T/S-Q	430	85.851	10.611	-0.877	0.660	48.00	100.00
Eng. Maint. T/S-K	429	86.615	7.772	-1.037	2.418	44.00	100.00
Clutches-Q	426	86.873	10.786	-1.229	2.286	32.00	100.00
Clutches-K	430	81.595	8.816	-0.551	0.295	50.00	100.00
Comprehensive Test3	425	78.581	8.452	-0.616	0.988	41.00	100.00

Table 54

Communalities, Factor Loadings and Factor Score Coefficients for EN Variables - Form B

Variable	Communality	Factor Loadings	Factor Score Coefficients
Eng. Fundmtls.-K	.303	.586	.130
Tech Manual-K	.365	.639	.143
Ship Elec./Comm.-K	.363	.648	.156
Shpbd. Fire Fight-K	.362	.603	.117
Comprehensive Test1	.525	.772	.268
Fuel/Start.Sys.-K	.304	.566	.123
Eng. Maint. T/S-K	.348	.610	.139
Clutches-K	.342	.571	.119
Comprehensive Test2	.355	.635	.146

Note. n = 423

Table 55

Descriptive Statistics for EN Composite Variables - Form B

Composite	n	Rel[a]	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
FSG[b]	469	N/A	83.522	5.885	-2.177	22.000	24.00	97.80
FSG2[c]	422	.877	83.918	5.706	0.077	-0.479	68.02	97.89
Phase 1[d]	437	.789	83.934	6.583	-0.190	-0.259	61.20	98.40
Phase 2[e]	424	.708	82.468	5.976	-0.123	0.078	62.80	97.20
PE[f]	453	.668	84.624	7.209	-0.320	-0.376	60.67	99.33
Quizzes[g]	426	.736	86.225	6.023	-0.369	0.073	66.50	99.60

[a]These are composites based on communality estimates and the procedures described in the text.
[b]FSG: Final School Grade computed by the EN school.
[c]FSG2: Final School Grade computed using initial test scores.
[d]Phase1: Average of all tests up to and including Comprehensive Test1.
[e]Phase2: Average of all tests up to and including Comprehensive Test2.
[f]PE: Average of all Propulsion Engineering tests (first 3 tests).
[g]Quizzes: Average of all Quizzes.

Next, we computed Pearson correlation coefficients for the composite variables. Table 56 presents the composite variable intercorrelations. Because FSG and FSG2 correlate .97, this offers no support for using initial test scores to compute FSG.

FSG correlates highest (.98) with Factor 1, followed by Phase 1 (.93), Phase 2 (.92), and PE (.86). Finally, Phase 1 and Phase 2 each correlate .91 with FSG, while PE correlates .84 with FSG. This supports using FSG as an indicator of Factor 1.

Table 56

Correlations Among EN Composites and Factors - Form B

Composite	Factor1	FSG[a]	FSG2[b]	Phase 1[c]	Phase 2[d]	PE[e]
FSG	.98					
FSG2	.98	.97				
Phase 1	.93	.91	.92			
Phase 2	.92	.91	.91	.74		
PE	.86	.84	.87	.93	.67	
Quizzes[f]	.80	.83	.87	.74	.75	.70

[a]FSG: Final School Grade computed by the EN school.
[b]FSG2: Final School Grade computed using initial test scores.
[c]Phase1: Average of all tests up to and including Comprehensive Test1.
[d]Phase2: Average of all tests up to and including Comprehensive Test2.
[e]PE: Average of all Propulsion Engineering tests (first 3 tests).
[f]Quizzes: Average of all Quizzes.

Results Form C. Table 57 presents the descriptive statistics for the set of variables used in the analysis of Form C. We conducted a factor analysis on the set of knowledge and comprehensive tests. The scree test and factor loadings indicated a one-factor solution. Table 58 shows the communalities, factor loadings, and factor score coefficients. Factor loadings ranged from .43 to .76.

We sought to develop composite variables which would capture essential elements of the criterion variance and also represent meaningful content dimensions useful to the EN school. We computed composite variables based on the three phases in the curriculum. Phase 1 included tests before comprehensive test 1 and including comprehensive test 1. Phase 2 consisted of all tests before comprehensive test 2 and including comprehensive test 2. Phase 3 consisted of all tests before comprehensive test 3 and including comprehensive test 3. We also computed a composite variable based on the Propulsion

Table 57

Descriptive Statistics for EN Variables - Form C

Variable	n	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
Eng. Fundmtls.-K	408	81.015	9.395	-0.495	0.430	40.00	100.00
Tech. Manual-K	399	84.887	8.647	-0.517	0.046	54.00	100.00
Ship Elec./Comm.-K	397	86.272	9.641	-0.826	0.577	48.00	100.00
Comprehensive Test1	395	82.522	9.619	-0.952	3.229	23.00	100.00
Diesel Engines-K	307	89.717	7.074	-1.255	3.070	50.00	100.00
Fuel/Start.Sys.-K	388	84.588	9.130	-0.546	-0.074	56.00	100.00
Air Start Sys.-K	387	85.824	7.640	-0.620	0.313	58.00	100.00
Comprehensive Test2	304	85.957	6.373	-0.275	-0.109	64.00	100.00
Clutches-K	386	84.288	10.013	-0.881	-0.880	46.00	100.00
Ship.Aux.Equip/Evaps-K	384	87.764	6.943	-0.653	0.623	62.00	100.00
Comprehensive Test3	300	84.430	7.047	-0.477	0.148	57.00	100.00

Table 58

Communalities, Factor Loadings and Factor Score Coefficients for EN Variables - Form C

Variable	Communality	Factor Loadings	Factor Score Coefficients
Eng. Fundmtls.-K	.214	.429	.053
Tech. Manual-K	.301	.558	.089
Ship Elec./Comm.-K	.409	.658	.136
Comprehensive Test1	.437	.690	.157
Diesel Engines-K	.334	.572	.084
Fuel/Start.Sys.-K	.390	.640	.112
Air Start Sys.-K	.389	.640	.127
Comprehensive Test2	.555	.759	.208
Clutches-K	.431	.660	.120
Ship.Aux.Equip/Evaps-K	.310	.552	.082
Comprehensive Test3	.483	.739	.181

Note. n = 300

Engineering (PE) exams. And finally, because the EN school computed the FSG using a 75 as the minimum score, we calculated our own Final School Grade (FSG2) using the initial test scores, and listed both as composite variables. Table 59 presents the descriptive statistics for the composite variables.

Next, we computed Pearson correlation coefficients for the composite variables. Table 60 presents the composite variable intercorrelations. Because

Table 59

Descriptive Statistics for EN Composite Variables - Form C

Composite	n	Rel[a]	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
FSG[b]	408	N/A	84.583	5.994	-1.458	8.800	40.00	96.70
FSG2[c]	300	.873	85.564	5.353	-0.126	-0.445	69.50	96.80
Phase 1[e]	395	.698	83.835	6.745	-0.405	0.062	58.75	97.00
Phase 2[f]	304	.754	86.762	5.656	-0.273	-0.219	68.25	99.00
Phase 3[g]	300	.699	85.891	6.175	-0.423	0.089	67.00	99.33
PE[h]	397	.586	84.238	6.921	-0.435	-0.062	63.33	98.00

[a]These are composites based on communality estimates and the procedures described in the text.
[b]FSG: Final School Grade computed by the EN school.
[c]FSG2: Final School Grade computed using initial test scores.
[d]Phase1: Average of all tests up to and including Comprehensive Test1.
[e]Phase2: Average of all tests up to and including Comprehensive Test2.
[f]Phase3: Average of all tests up to and including Comprehensive Test3.
[g]PE: Average of all Propulsion Engineering tests (first 3 tests).

Table 60

Correlations Among EN Composites and Factors - Form C

Composite	Factor1	FSG[a]	FSG2[b]	Phase 1[c]	Phase 2[d]	Phase3[e]
FSG	.98					
FSG2	.99	.98				
Phase 1	.84	.85	.88			
Phase 2	.90	.87	.89	.65		
Phase 3	.87	.85	.85	.62	.70	
PE[f]	.78	.79	.84	.96	.60	.57

[a]FSG: Final School Grade computed by the EN school.
[b]FSG2: Final School Grade computed using initial test scores.
[c]Phase1: Average of all tests up to and including Comprehensive Test1.
[d]Phase2: Average of all tests up to and including Comprehensive Test2.
[e]Phase3: Average of all tests up to and including Comprehensive Test3.
[f]PE: Average of all Propulsion Engineering tests (first 3 tests).

FSG and FSG2 correlate .98, this offers no support for using initial test scores to compute FSG.

FSG correlates .98 with Factor 1, followed by Phase 2 (.90), Phase 3 (.87), Phase 3 (.84), and PE (.78). Finally, Phase 1, Phase 2, and Phase 3

correlate .85, .87, and .85 with FSG, respectively. PE correlates .79 with FSG. This supports using FSG as an indicator of Factor 1.

In summary, due to changes in the course curriculum and type of instruction, we separated the EN school into three forms. Based on the results, however, we found the school performance measures to be unidimensional for each form. Results for each of the three forms also supports using the FSG as an indicator of performance in the school.

Recommendations. We recommend using the FSG as an indicator of performance in the EN school.

Fire Control (FC)

Description of Variables. The FC school provided hard-card data for students tested through September 1990 and the ISS Response History Report for students tested after September 16, 1990. The data format variable in the database distinguishes between the two types of student data.

The hard-card data does not always have the class convening date on the forms. Therefore, RGI entered the first test date (Julian date 90101 - 90240) rather than the class convening date for students with hard-card data, except classes 91277 and 91283, which were pilot classes. RGI entered the class registration date (Julian date 90000 - 92366) for students with ISS data and for classes 91277 and 91283.

The school uses a multiple choice, written test format and administers tests only on Fridays. Therefore, some students may not take all tests for various reasons (such as when a government holiday falls on a Friday). The school requires a 70% to pass each test. Students who fail a test must take a retest over the problem areas after remediation. The school allows two retests per test. Students who fail both retests must appear before the Academic Review Board. As of June 1991, the school administers retests on Saturday mornings instead of later on the same day of testing (Friday). According to instructors, this extra time for studying greatly improved retest scores. The school assigns the minimum passing score to all retests the student passes. However, RGI entered the initial score for each test.

We excluded Modules 601 and 602 from the analyses, because we could not determine whether a student received an open or closed-book test. The school left the method of testing to the discretion of the instructors. We also excluded both of the Control Systems tests (CS1 and CS2) and the Fire Control

Problem (FCP) test. Only 25 students took these tests and all 25 students were missing the registration Julian date.

The school calculates the Final School Grade by adding all of the module test scores together and dividing the total by the number of tests administered to the student.

The school made several changes to the curriculum during the time RGI collected data. These changes involved renumbering tests, consolidating and splitting test material, and adding and subtracting tests and test material. Table 61 describes the tests and curriculum changes. Notes in Table 61 indicate when and where these changes occurred.

For each test variable, Table 61 identifies the ISS name (e.g., variable number 101), if available, and the most commonly used hard-card name (e.g., DC1), followed by a short description and the name we assigned to the variable.

Sample. The initial sample consisted of 858 students who began training between August 1990 to November 1991. Most of the changes to the curriculum occurred after Julian date 91283. A preliminary analysis found only 11 cases with data after Julian date 91283. Also, 157 cases were missing a registration date and 218 were missing complete data. Because of the small number of students registered after 91283, we conducted analyses based on students who registered before 91283. The final sample consisted of 483 students with complete data.

Results and Discussion. Table 62 presents the descriptive statistics for the set of variables used in the analyses. We conducted a factor analysis on the set of knowledge and comprehensive tests. We excluded Digits1 to Elecro-Mech.3 due to the small number of cases that had those variables. The scree test and the factor loadings indicated a two factor solution. Table 63 shows the

Table 61

Descriptions of FC Variables

Test No.	Description (Name)
101	**DC1 (Direct Current Circuits 1)**: Introduction to Fire Control: Knowledge of matter and energy; knowledge, comprehension, and application of metric notation and electrical characteristics. (DC Circuits1)
102	**DC2 (Direct Current Circuits 2)**: Knowledge and comprehension of batteries and electrical safety; application of series DC circuits. (DC Circuits2)
103	**DC3 (Direct Current Circuits 3)**: Knowledge, comprehension, and application of basic meters, multimeters (Simpson), and series circuit fault isolation. (DC Circuits3)
104	**DC4 (Direct Current Circuits 4)**: Knowledge, comprehension, and application of DC parallel circuits and DC series-parallel circuits. (DC Circuits4)
105	**DC5 (Direct Current Circuits 5)**: Knowledge, comprehension, and application of DC series-parallel circuits and voltage dividers. (DC Circuits5)
106	**AC1 (Alternating Current Circuits 1)**: Knowledge and comprehension of AC generation: knowledge, comprehension, and application of AC wave forms and AC test equipment. (AC Circuits1)
107	**AC2 (Alternating Current Circuits 2)**: Knowledge, comprehension, and application of inductors, inductance circuits, and resistive/inductive circuits. (AC Circuits2)
108	**AC3 (Alternating Current Circuits 3)**: Knowledge, comprehension, and application of capacitance, capacitive reactance, series resistive/capacitive circuits, and parallel resistive/capacitive circuits. (AC Circuits3)
109	**AC4 (Alternating Current Circuits 4)**: Knowledge, comprehension, and application of series resistive/inductive/capacitive circuits, parallel resistive/inductive/capacitive circuits, AC power, series resonance, parallel resonance, and tuning. (AC Circuits4)
110	**AC5 (Alternating Current Circuits 5)**: Knowledge, comprehension, and application of complex filters and transformers: knowledge and comprehension of circuit protection devices and circuit control. (AC Circuits5)
201	**FCE1 (Tubes)**: Knowledge and comprehension of tubes: knowledge, comprehension, and application of special tubes and tube biasing. (Tubes)
202	**FCE2 (Transistors)**: Knowledge, comprehension, and application transistors, field effect transistors, and special devices. (Transistors)
Before class 91283, the school taught Amplifiers I and II before Power Supplies.	
203	**FCE3 (Amplifiers I)**: Knowledge of common emitter amplifiers, amplifier configurations, and classes of operation: knowledge, comprehension, and application of linear integrated circuits, operational amplifiers, and special design amplifiers. (Amplifiers1)
204	**FCE4 (Amplifiers II)**: Knowledge, comprehension, and application of amplifier coupling, amplifier frequency range, and amplifier troubleshooting. (Amplifiers2)
205	**FCE5 (Power Supplies)**: Knowledge, comprehension, and application of basic power supplies, power supply transformers, rectifiers, power supply filters, regulation and regulators, and introduction to solid state power supplies. (Power Supplies)
206	**FCE6 (Oscillators)**: Knowledge, comprehension, and application of crystal oscillators, resistive/capacitive phase shift oscillators, Wein-Bridge oscillators, and blocking oscillators. (Oscillators)
207	**FCE7 (Multivibrators)**: Knowledge, comprehension, and application of bistable multivibrators, monostable multivibrators, astable multivibrators, and Schmitt Trigger multivibrators. (Multivibrators)

Table 61 (Continued)

Test No.	Description (Name)
208	**PCE8 (Special Circuits)**: Knowledge, comprehension, and application of coincidence circuits, sawtooth circuits, limiters, and clampers. (Special Circuits)
209	**PCE9 (Superhet 1)**: Knowledge, comprehension, and application of AM modulators, FM modulators, mixers, detectors, and discriminators. (Superhet1)
210	**PCE10 (Solder/Desolder)**: Knowledge, comprehension, and application of solder/desolder techniques, high reliability soldering, wiring, cable, and electro-static discharge. (Solder)
301	**DG1 - Digits 1**: Knowledge and comprehension of number systems and logic circuits. (Digits1)
302	**DG2 - Digits 2**: Knowledge of flip flop; knowledge, comprehension, and application of digital counters, registers/converters, and adders/subtractors. (Digits2)
303	**DG3 - Digits 3**: Knowledge, comprehension, and application of timers/comparators/parity; knowledge, comprehension, and application of I-O/multiplexers/encoders/decoders/storage devices; knowledge of digital computers/flow charting. (Digits3)
401	**EM1 - Electro-Mechanical 1**: Knowledge, comprehension, and application of AC/DC generators, tachomotors/AC and DC motors, Amplidynes/motor and generator safety/ maintenance; knowledge comprehension, and application of thermal protection/nameplate parameters/noise and vibration. (Electro-Mech.1)
402	**EM2 - Electro-Mechanical 2**: Knowledge, comprehension, and application of torque synchros, troubleshooting synchros, torque differential synchros, and control synchros; knowledge and comprehension of scale factors, electronic computing elements, summation loops, multipliers-dividers, and resolvers. (Electro-Mech.2)
403	**EM3 - Electro-Mechanical 3**: Knowledge, comprehension, and application of servo mechanisms, servo power systems, operation, gyroscopes, rate gyros/accelerometers, and intro/operations of director systems. (Electro-Mech.3)

Prior to March 18, 1991, Radar (Unit 500) lasted 5 weeks. On this date, the school discontinued troubleshooting procedures and laboratory exercises. This cut the Radar unit from 5 weeks to four weeks in length. The school never administered tests covering this material, therefore, the tested course content remained the same.

501	**R1 (Radar 1)**: Knowledge of safety/hazards/security, intro/basics/subsystems, range/bearing/elevation, resolution/accuracy, pulsed/pulsed Doppler/FM-CW Doppler, timing, and synchronizer operations/outputs/maintenance. (Radar1)
502	**R2 (Radar 2)**: Knowledge, comprehension, and application of indicators, indicator maintenance, transmission lines/quarter wave lines, waveguide/microwave components, klystrons, traveling wave tubes, and magnetrons/amplitrons. (Radar2)
503	**R3 (Radar 3)**: Knowledge, comprehension, and application of transmitters, modulation, transmitter maintenance, antennas/servos/maintenance/halfwave antennas, and duplexers/devices/reflex klystrons. (Radar3)
504	**R4 (Radar 4)**: Knowledge, comprehension, and application of receiver theory/maintenance/radar ranging, dry air/liquid cooling, cooling-plumbing/power distribution. (Radar4)

Table 62

Descriptive Statistics for FC Variables

Variable	n	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
DC Circuits1	848	85.512	8.334	-0.773	0.488	50.00	100.00
DC Circuits2	839	83.914	8.499	-0.513	0.015	54.50	100.00
DC Circuits3	839	83.371	11.005	-1.300	4.970	10.00	100.00
DC Circuits4	830	85.542	12.546	-1.408	2.726	12.50	100.00
DC Circuits5	819	81.391	13.397	-1.251	2.482	25.00	100.00
AC Circuits1	806	87.437	8.849	-1.773	9.845	10.00	100.00
AC Circuits2	801	88.987	8.727	-1.865	10.449	6.70	100.00
AC Circuits3	790	81.648	11.286	-0.756	0.709	35.70	100.00
AC Circuits4	777	83.112	12.221	-1.115	1.915	20.80	100.00
AC Circuits5	778	83.458	8.484	-0.593	0.562	45.00	100.00
Tubes	764	79.282	10.190	-0.400	0.196	32.50	100.00
Transistors	772	78.304	11.783	-0.532	0.182	25.00	100.00
Amplifiers1	752	75.342	11.725	-0.453	0.055	37.50	100.00
Amplifiers2	734	79.402	9.873	-0.403	0.138	40.00	100.00
Power Supplies	736	83.864	8.561	-0.499	0.331	50.00	100.00
Oscillators	713	76.914	10.430	-0.792	1.518	17.50	100.00
Multivibrators	703	77.418	11.427	-0.538	0.546	30.00	100.00
Special Circuits	693	83.604	9.532	-0.621	0.106	47.50	100.00
Soldernet1	690	88.572	9.326	-1.159	3.064	25.00	100.00
Solder	688	89.012	9.007	-2.562	17.306	10.00	100.00
Digits1	104	91.270	6.970	-1.276	2.230	65.79	100.00
Digits2	104	87.863	8.969	-1.316	2.948	53.13	100.00
Digits3	104	85.549	7.316	-0.656	0.981	57.58	100.00
Electro-Mech1	104	82.654	8.806	-0.704	0.690	50.00	98.00
Electro-Mech2	104	80.457	8.718	-0.366	-0.166	60.00	97.83
Electro-Mech3	104	83.660	6.873	-0.561	0.373	63.89	97.27
Radar1	667	76.956	8.772	-0.307	-0.036	45.50	100.00
Radar2	667	84.682	9.876	-0.697	1.228	28.10	100.00
Radar3	670	81.554	10.726	-0.602	0.115	39.40	100.00
Radar4	672	81.732	10.278	-0.663	1.157	25.90	100.00

communalities, factor loadings, and factor score coefficients. Based on the results of the factor analysis, we labeled the first factor Circuits and Electrical Devices (Circuits/Devices) and the second factor Radar.

To examine whether a Circuits/Devices versus a Radar distinction could explain aspects of school performance, we computed a composite variable based on the average of all the Circuits/Devices variables (DC Circuits1 to Special Circuits) and a composite based on the average of all the Radar variables (Radar1 to Radar4). Additional composites included the Sum1 and Sum2 composites which

Table 63

Communalities, Factor Loadings, and Factor Score Coefficients for FC Variables

Variable	Communality	Factor Loadings		Factor Score Coefficients	
		Factor 1: Circuits/Devices	Factor 2: Radar	Factor 1: Circuits/Devices	Factor 2: Radar
DC Circuits1	.273	.490	.180	.103	-.035
DC Circuits2	.265	.478	.189	.096	-.028
DC Circuits3	.294	.498	.211	.103	-.022
DC Circuits4	.426	.653	.000	.244	.186
DC Circuits5	.308	.524	.181	.117	-.045
AC Circuits1	.250	.447	.225	.074	-.002
AC Circuits2	.282	.503	.170	.107	-.039
AC Circuits3	.401	.544	.324	.107	.008
AC Circuits4	.281	.430	.310	.047	.042
AC Circuits5	.346	.427	.405	.041	.077
Tubes	.413	.523	.373	.077	.051
Transistors	.468	.619	.291	.158	-.033
AMP1	.338	.434	.387	.038	.080
AMP2	.408	.458	.445	.040	.106
POWRSUP	.158	.313	.244	.035	.019
Oscillators	.403	.537	.339	.096	.035
Multivibrators	.378	.520	.327	.087	.021
Special Circuits	.324	.412	.393	.028	.082
Superhet1	.112	.128	.310	-.023	.075
Solder	.053	.094	.211	-.012	.051
Radar1	.353	.242	.543	-.056	.197
Radar2	.239	.165	.460	-.052	.146
Radar3	.334	.199	.542	-.072	.204
Radar4	.434	.091	.653	-.156	.331

Note. $n = 483$

took a simple average of all the variables that loaded .30 or greater on Factor 1 and Factor 2, respectively.

We also calculated a composite based on the average of Digits1 to Digits3 and a composite based on the average of Electro1 to Electro4. Correlations among the Digit variables ranged from .30 to .35, while correlations among the Electro-Mech variables ranged from .26 to .46. We included the Digits and Electro-Mech composites in a correlation matrix in order to assess their contribution to the overall variance.

Because the FC school computed the FSG using a 70 as the minimum score, we calculated our own Final School Grade (FSG2) using the initial test scores, and listed both as composite variables. Table 64 shows the descriptive statistics for the composite variables.

We then computed Pearson correlation coefficients for the composite variables. Table 65 presents the composite variable intercorrelations. Because FSG and FSG2 correlate .99, this offers no support for using initial test scores to compute FSG.

Circuit/Devices and Sum1 correlate highest (.94) with Factor 1, followed closely by FSG (.85). Similiarly, Radar correlates highest (.93) with Factor 2, followed by Sum2 (.87). These findings support using the logical combinations of tests to assess the dimensions reflected in the factor analysis.

Table 64

Descriptive Statistics for FC Composite Variables

Composite	Rel[a]	Mean	Std Dev	Skew	Kurtosis	Min	Max
Sum1[b]	.895	83.059	5.890	.130	-.677	68.18	97.63
Sum2[c]	.866	81.772	5.833	.121	-.196	65.41	98.02
FSG	N/A	83.094	6.003	-.497	1.181	50.00	97.70
FSG2[d]	.924	84.835	4.906	.005	-.178	70.87	97.18
Radar[e]	.675	82.390	7.029	-.342	.099	55.61	100.00
Circ./Devices[f]	.893	83.450	5.739	.114	-.654	69.59	97.75
Digits[g]	.630	88.227	5.753	-.775	.478	71.03	97.98
Elec. Mech.[h]	.596	82.257	6.112	-.228	-.091	66.07	95.83

Note. n = 483

[a]These are composites based on communality estimates and the procedures described in the text.

[b]Sum1: Average of all tests loading .30 or greater on Factor 1.

[c]Sum2: Average of all tests loading .30 or greater on Factor 2.

[d]FSG2: Average of all tests using initial test scores.

[e]Radar: (Average of all Radar tests.

[f]Circ./Devices: Average of DC Circuit1 to Special Circuit tests.

[g]Digits: Average of all Digit tests.

[h]Elec. Mech.: Average of all Electro-Mech. tests.

Table 65

Correlations Among FC Composites and Factors

Composite	Factor1	Factor2	Sum1[a]	Sum2[b]	FSG	FSG2[c]	Radar[d]	Circ./ Devices[e]	Digits[f]
Factor2	.40								
Sum1	.94	.67							
Sum2	.76	.87	.92						
FSG	.85	.78	.95	.95					
FSG2	.85	.80	.96	.96	.99				
Radar	.44	.93	.67	.83	.78	.80			
Circ./Devices	.94	.68	.99	.93	.96	.97	.67		
Digits	.52	.61	.63	.68	.72	.75	.59	.63	
Elec. Mech.[g]	.48	.65	.61	.68	.73	.73	.64	.61	.54

[a]Sum1: Average of all tests loading .30 or greater on Factor 1.
[b]Sum2: Average of all tests loading .30 or greater on Factor 2.
[c]FSG2: Average of all tests using initial test scores.
[d]Radar: Average of all Radar tests.
[e]Circ./Devices: Average of DC Circuit1 to Special Circuit tests.
[f]Digits: Average of all Digit tests.
[g]Elec. Mech.: Average of all Electro-Mech. tests.

Finally, FSG correlates .96 with Circuits/Devices and .78 with Radar. These findings support using FSG as an indicator for performance on Circuits/Devices tests but suggest using a separate indicator for performance on Radar tests.

Recommendations. In addition to FSG, use an average of all Radar tests.

Gunner's Mate - Gun (GMG)

Description of Variables. The GMG school generates all written tests with the COGENT (Computer Generated Testing System) microcomputer program. The COGENT program makes each test unique by randomly selecting multiple choice questions from a content area test bank. The school predetermines the material covered and the number of questions required for each test. The GMG school currently generates test scores through ISS and has since June 17, 1991. We received only data for students with a convening date before June 17, 1991, and therefore the data was all hard card data.

The school scores all tests on a scale of 0.00 to 100.00 and requires a minimum passing score of 75. Students scoring below 75 have the option to take a retest. Those choosing not to take a retest keep their initial score. For students who choose to take a retest and pass, the school assigns a minimum passing score of 75. When a student fails an individual test twice, the student must go before the Academic Review Board. The hard card data we received did not include initial test scores. Therefore, we entered the assigned score of 75 when the student passed a retest.

Table 66 provides a description of the GMG school tests for both hard card and ISS tape data. For hard card data, the school calculated the Final School Grade (FSG) by dividing the sum of the test scores by the number of tests given. For ISS tape data, the school now uses the following weighted average: Tests 1-10 each constitute 2.9% of the FSG; Tests 11-25 each constitute 3.2% of the FSG; and Test 27 constitutes 20% of the FSG.

Table 66

Descriptions of GMG Variables

Test No.	Description (Name)
	All tests are written tests
1	Mathematics (Math)
2	Matter and Energy, Electromotive Force and Energy, Resistance and Resistors, Electrical Safety, Schematics, and Multimeter Usage (Energy)
3	Series DC Circuits (Series DC)
4	Parallel DC Circuits (Parallel DC)
5	Magnetism, AC Generation, Wave Form Analysis, and Oscilloscopes (Magnetism)
6	Inductors and Inductance, RL Circuits, and Transformers (Inductors)
7	Capacitors and Capacitance, RC Circuits, and RLC Circuits (Capacitors)
	(Beginning July 30, 1991, the school split content areas from Tests 8 and 9 to make up Test 10, and designated Test 111 as the new comprehensive exam. The school did not change the content areas with these changes.)
8	Electrical Connections, Semiconductors, General Transistors, and Transistor Configurations (through July 30, 1991). (Transis.)
9	Rectifier Circuits, Filter Circuits, Special Devices, Integrated Circuits (through July 30, 1991). (Rectifiers);
10	Comprehensive test over materials covered on tests 1-9 (through July 30, 1991). (Comp 1)
11	Digits 1
12	Digits 2
13	Motors and Generators (Motor/Gen)
14	Special Circuits (Sp. Circ)
15	Hydraulics 1 (Hydr. 1)
16	Hydraulics 2 (Hydr. 2)
17	Servos/Synchros Systems (Serv/Syn)
18	Missile Systems (Missiles)
19	Ammunition (Ammo.)
20	Magazines and Sprinklers (Mag/Sprink)
21	Gun Mounts (Gun Mts)
22	Tag-Out
23	3M Maintenance (3M)
24	Handtools
25	Small Arms (S. Arms)
27/30	Comprehensive test over material covered on tests 10-25. (Test 27 corresponds to ISS tape data, and Test 30 corresponds to hard card data. Although the tests have different numbers, the material covered is identical.) (Comp 2)

Sample. The sample consisted of 301 students who began the GMG curriculum before June 17, 1991. We excluded from some analyses the 55 cases that did not take every test.

Results and Discussion. We computed descriptive statistics for each of the test variables. Table 67 lists the descriptive statistics for all variables.

Table 67

Descriptive Statistics for GMG Variables

Variable	n	Mean	Std Dev	Skew	Kurtosis	Minimum	Maximum
Math	301	88.768	8.036	-1.505	5.051	38.46	100.00
Energy	301	83.610	8.561	- .180	- .197	51.15	100.00
Series DC	301	88.686	8.426	- .749	.006	59.38	100.00
Parallel DC	301	81.533	10.287	- .689	1.266	37.50	100.00
Magnetism	301	88.245	7.800	- .740	.304	62.50	100.00
Inductors	301	89.175	8.088	- .640	- .187	62.50	100.00
Capacitors	301	83.479	8.528	- .172	- .312	53.13	100.00
Transis.	301	83.388	9.356	- .613	.438	43.18	100.00
Rectifiers	298	82.886	8.913	- .558	.425	50.00	100.00
Comp. 1	298	79.443	8.353	- .086	- .317	55.56	100.00
Digits 1	286	90.724	8.581	-1.060	.668	55.56	100.00
Digits 2	277	83.974	11.742	- .948	.922	39.29	100.00
Motor/Gen.	278	86.322	7.974	- .618	.484	59.38	100.00
Spec. Circ.	274	86.253	8.124	- .789	1.635	44.44	100.00
Hydr. 1	268	84.849	9.448	- .778	.651	50.00	100.00
Hydr. 2	259	88.845	7.565	- .789	.951	55.26	100.00
Serv/Syn.	259	85.874	9.377	- .902	1.051	50.00	100.00
Missiles	259	94.079	5.521	-1.061	.892	75.00	100.00
Ar[illegible]o.	259	88.987	8.101	- .750	.357	61.36	100.00
Mag/Sprnk.	254	92.854	6.279	-1.083	1.162	66.67	100.00
Gun Mts.	254	94.728	5.775	-1.302	1.220	75.00	100.00
Tag-out	253	90.909	7.907	-1.158	2.371	50.00	100.00
3M	249	87.494	9.436	- .834	.719	52.78	100.00
Handtools	249	93.516	6.041	-1.392	1.819	70.83	100.00
S. Arms	249	85.133	8.850	- .585	.442	50.00	100.00
Comp. 2	249	68.550	9.173	.351	.157	43.00	100.00

Next, we conducted a factor analysis on the set of all test variables. The scree test and the factor loadings indicated two factors. Based on the results of the factor analysis, we labeled the first factor 1st Half and the second factor 2nd Half. Tests 1 to 13 (up through Motor/Gen. in Table 66) loaded higher on Factor 1 and tests 15 to 27/30 loaded higher on Factor 2. Test 14 (Spec. Circ.) loaded about evenly on both factors. Table 68 lists the communalities, factor loadings, and factor score coefficients for each of the variables.

Table 68

Communalities, Factor Loadings, and Factor Score Coefficients for GMG Variables

Variable	Communality	Factor Loadings Factor 1: 1st Half	Factor Loadings Factor 2: 2nd Half	Factor Score Coefficients Factor 1: 1st Half	Factor Score Coefficients Factor 2: 2nd Half
Math	.209	.437	.139	.086	-.034
Energy	.380	.597	.155	.169	-.073
Series DC	.393	.608	.151	.180	-.087
Parallel DC	.408	.622	.147	.192	-.091
Magnetism	.273	.468	.234	.094	-.021
Inductors	.217	.357	.299	.040	.019
Capacitors	.361	.556	.227	.135	-.033
Transis	.416	.516	.386	.098	-.017
Rectifiers	.366	.471	.380	.082	.032
Comp. 1	.441	.606	.271	.163	-.043
Digits 1	.307	.509	.220	.112	-.031
Digits 2	.326	.502	.270	.106	-.014
Motor/Gen	.320	.424	.374	.052	.039
Spec. Circ.	.248	.333	.370	.029	.041
Hydr. 1	.375	.348	.503	.010	.096
Hydr. 2	.323	.270	.500	-.014	.100
Serv/Syn.	.286	.347	.406	.031	.054
Missiles	.270	.202	.478	-.029	.099
Ammo.	.396	.193	.599	-.066	.169
Mag/Sprink.	.345	.156	.567	-.060	.146
Gun Mts.	.307	.221	.509	-.030	.110
Tag-out	.442	.039	.664	-.150	.250
3M	.346	.312	.499	.001	.099
Handtools	.347	.226	.544	-.035	.129
S. Arms	.324	.257	.508	-.024	.102
Comp.2	.420	.359	.539	.003	.122

Note. n = 246

In order to determine whether the separation of the course curriculum could explain aspects of student performance, we created a 1st Half composite variable, which was an average of tests 1 to 14, and a 2nd Half composite variable which was an average of tests 14 to 27/30. We included test 14 (Spec. Circ.) in both composites because it loaded about equally high on both factors. The school gives a comprehensive test over the material covered by tests 1-9 and a comprehensive test over the material covered by tests 11-25. We created two composite variables, Phase1 and Phase2, based on this separation also. Additional composites included the Sum1 and Sum2 composite variables which took

a simple average of all tests that loaded .30 or greater on either Factor 1 or Factor 2, respectively. We included tests that loaded above .30 on both Factor 1 and Factor 2 in the averages for both composite variables. We also added the student's FSG as a composite variable. We did not compute our own FSG because initial test scores were not available. We used the factor scores, Factor 1 and Factor 2, as additional composite variables. Table 69 lists the descriptive statistics for each of the composite variables listed above. The n varied for the composite variables depending on the number of tests missing for each case.

Table 69

Descriptive Statistics For GMG Composite Variables

Composite	n	Rel[a]	Mean	Std Dev	Skew	Kurtosis	Min	Max
Sum1[b]	247	.89	84.812	5.273	.000	-.533	73.17	97.50
Sum2[c]	247	.89	87.247	4.860	-.081	-.474	72.89	97.81
FSG	301	.92	86.340	4.893	-.030	-.539	73.15	98.02
Half1[d]	273	.87	85.572	5.266	.016	-.635	74.23	97.26
Half2[e]	247	.87	87.890	4.835	-.178	-.398	72.21	98.25
Phase1[f]	298	.84	84.918	5.455	-.013	-.510	72.25	97.93
Phase2[g]	246	.88	87.775	4.848	-.106	-.590	74.04	98.38

[a]These are composites based on communality estimates and the procedures described in the text.
[b]Sum1: Average of Tests with Factor 1 loadings greater than .30.
[c]Sum2: Average of Tests with Factor 2 loadings greater than .30.
FSG: Student's FSG using retest scores.
[d]Half1: Average of Tests 1-14.
[e]Half2: Average of Tests 14-27/30.
[f]Phase1: Average of Tests 1-10.
[g]Phase2: Average of Tests 11-27/30.

Table 70

Correlations Among GMG Composites and Factors

Comp	Factor1	Factor2	Sum1[a]	Sum2[b]	FSG	Half1[c]	Half2[d]	Phase1[e]	Phase2[f]
Factor1	--								
Factor2	.17	--							
Sum1	.88	.59	--						
Sum2	.56	.90	.87	--					
FSG	.78	.74	.98	.94	--				
Half1	.93	.48	.98	.79	.93	--			
Half2	.48	.93	.82	.98	.91	.72	--		
Phase1	.93	.42	.93	.74	.90	.96	.66	--	
Phase2	.58	.87	.88	.98	.95	.80	.97	.71	--

[a]Sum1: Average of Tests with Factor 1 loadings greater than .30.
[b]Sum2: Average of Tests with Factor 2 loadings greater than .30.
FSG: Student's FSG using retest scores.
[c]Half1: Average of Tests 1-14.
[d]Half2: Average of Tests 14-27.
[e]Phase1: Average of Tests 1-10.
[f]Phase2: Average of Tests 11-27/30.

Finally, we computed Pearson correlation coefficients for the composite variables. Table 70 provides the intercorrelations between all composite variables. Half1 and Phase1 both correlate .93 with Factor1, followed by Sum1 (.88). Half2 correlated highest with Factor2 (.93), followed by Sum2 (.90) and Phase2 (.87). This supports using the logical combination of variables to measure the factors observed. Finally, FSG correlates .78 and .74, respectively, with Factor1 and Factor2 but .93 and .94 with Half1 and Half2.

Recommendations. In addition to FSG, use an average of all Half1 tests and average of all Half2 tests.

Machinist's Mate (MM1)

Before September 27, 1990, all MM students took Propulsion Engineering Basics (PE) as a prerequisite course. Instruction for the PE and the MM courses took place in the same building of the Great Lakes, IL Service School Command. Civilian personnel taught PE, and military personnel taught MM. As of September 27, 1990, the MM school incorporated the PE course into the MM course program. As a result of this merger, teaching responsibilities for the PE course shifted from civilian to military personnel. However, the PE course content and its presentation schedule did not change at this time.

On January 7, 1991, the school revised the MM curriculum to further integrate the PE and MM course material. The present section covers students entering the MM school before January 7, 1991, when the PE and the MM course material remained distinct. We labeled this curriculum MM1. The subsequent curriculum, MM2, addresses students entering the MM school after the instructors integrated the PE and the MM course material (January 7, 1991).

Description of Variables. Table 71 presents the MM1 tests and their corresponding descriptions. The MM school assesses student progress using written knowledge and comprehensive tests. The tests have a valid range of 0 to 100. Within the MM1 curriculum, the first six tests cover PE material. The remaining eight tests address MM issues. The school requires a score of 75% or higher to pass each exam. Examinees who fail a test participate in instructor oral remediation, night study, and retesting. Students cannot retest until the next academic day. All students who fail the retest appear before the Academic Review Board. The school then decides upon the student's status. The instructor assigns the minimum passing score to those students who pass the retest, and the school uses that minimum score in calculating the final school grade (FSG).

Table 71

Descriptions of MM1 Variables

Var. No.	Description (Name)
105	**Knowledge Test**: Personnel qualification standards/communication department watch organization, introduction to shipboard piping systems, piping system components, tag-out (Piping System)
109	**Knowledge Test**: Firemain/auxiliary cooling water, main drain potable & waste water system, twin agent system, halon fire system (Water System)
114	**Knowledge Test**: Maintenance & material management system (3-M), equipment technical manuals, hand tools/metal fastners, lubricants/packing/gaskets/insulation (3-M System)
117	**Knowledge Test**: Valves, couplings/gears/bearings, rotary/jet/centrifugal/reciprocating pumps (Valves)
122	**Knowledge Test**: Lubrication system, lube oil quality program/fill/transfer/purification, introduction to cold iron (Lube System)
125	**Comprehensive Test 1**: Introduction to piping systems, piping systems, intro to maintnance, maintenance, lube oil system, cold iron (PE Comp)
100	**Knowledge Test**: Basic steam cycle, energy curve, flue gas/water/steam path, fuel oil system (Steam Cycle)
200	**Knowledge Test**: Basic engineering terms, combustion air, superheater protection steam/main steam auxiliary/reduced pressure (Engineering)
300	**Knowledge Test**: Turbine theory terms, turbines, mail reduction gear/shafting/lube oil, purification and transfer, lube oil quality management (Turbine Theory)
400	**Knowledge Test**: Gland seal/exhaust purpose, gland seal & assembly, regulating station, main condenser/seawater circulation theory, propeller pump (Gland Seal)
500	**Knowledge Test**: Pump theory terms, main air removal/condensate/feed, deaerating feed tank, freshwater collecting tank, high pressure drain system, auxiliary exhaust system (Pump Theory)
600	**Knowledge Test**: Distilling plant, excess/make-up/reserve feed, escape steam system, physical/chemical properties of water, corrosion factors, shipboard water cycle, condensate/feedwater analysis, boiler lay-ups (Steam System)
700	**Knowledge Test**: Ship service turbo generator components, basic electricity theories & circuit, A.C. generator, ships service power distribution system, sources of electrical energy, alarm system (Generator)
800	**Comprehensive Test 2**: Generation, steam systems, turbine theory/drive train, gland seal/exhaust, main condenser/condensate/feed, distilling plant/water chemistry, electricity (MM Comp)

Note. The school computes a PE grade and an MM grade as:
PE Grade = .8 (mean of Piping System, Water System, 3-M System, Valves, and Lube System) + .2(PE Comp).
MM Grade = .8 (mean of Steam Cycle, Engineering, Turbine Theory, Gland Seal, Pump Theory, Steam System, and Generator) + .2(MM Comp).
The school computes FSG as the mean of the PE Grade and the MM Grade.

Although the MM school assigns a score of 75 for all successful retests, for the purpose of the present study, RGI entered all initial test scores into the database.

For each student, the school computes a PE grade and an MM grade from a weighted average of the corresponding knowledge and comprehensive test scores. The school uses the mean of the PE grade and the MM grade as the FSG. See Table 71 for tests weights.

Sample. The initial sample contained 373 students who began training between April 1990 and January 1991. The school merged the PE course with the MM course while the MM1 curriculum was in effect. Civilian instructors taught PE to the earlier students of the MM1 format (n=66) and military personnel taught PE to students who took the course later (n=307).

Results and Discussion. We began by testing the two groups of students for differences due to the change in PE instructors. We conducted a multivariate analysis of variance (MANOVA) to test the correlation matrices of the test scores. A test for homogeneity of covariance matrices revealed that the two forms had significantly different covariance matrices ($F=1.67$, $p<.001$). The test means also differed significantly across the two forms ($F=2.63$, $p<.001$). Univariate F-tests indicated that all variables differed between forms at the $p<.05$ level (except the following tests: 3-M System, Lube System, and Steam System). These findings indicate that the two samples come from two distinct populations.

To test whether ability accounted for these differences between the two groups of students, RGI conducted a multivariate analysis of covariance (MANCOVA) using the students' pre-enlistment ASVAB scores as covariates. After partialling out the variance due to ASVAB scores, test for homogeneity of covariance matrices

revealed different matrices for the two forms ($F=1.19$, $p<.05$). Test means also differed across the two forms after controlling for ASVAB scores ($F=2.56$, $p<.01$). These results suggest that the noted difference between the two groups is due to something other than differences in ability. Based on these findings, RGI analyzed each group separately.

To further evaluate the conclusion of differences between groups, we computed effect sizes (ES) as measures of the practical significance of the differences between the unadjusted means across groups. Cohen and Cohen (1977) state that .2 represents a small effect size, .5 is medium, and .8 is large. For a total of 14 comparisons between the MM groups, we found 1 ES within the .00 to .19 range, 11 ESs within the .20 to .49 range, and 2 ESs within the .50 to .79 range. These results show that 85% of the ESs fall below a value of .50. Thus, while the MANOVA tests indicate that the groups differ from one another in terms of statistical significance, the ESs suggest small magnitudes of the differences, in terms of practical significance.

Within the MM1 curriculum, Form 1 contains students who took the PE course separately, under civilian instruction (n=66). Form 2 contains students taking the PE course as the first part of the MM course, under military instruction (n=307). Form 1 included two cases with missing data. RGI excluded these cases from some of the analyses, resulting in a final sample size of 64 cases for Form 1. Form 2 included 23 cases with missing data. Likewise, we excluded these cases from some analyses, resulting in a final sample size of 284 cases for Form 2.

RGI computed descriptive statistics for each of the test variables. Table 72 presents these statistics, listing them separately for Form 1 and Form 2. Next, we conducted a factor analysis on each form separately. We included the

Table 72

Descriptive Statistics for MM1 Variables

Variable	n	Mean	Std Dev	Skew	Kurtosis	Min	Max
Form 1							
Piping System	66	88.182	10.227	-1.285	1.022	56.00	100.00
Water System	66	88.061	10.519	-1.638	2.282	56.00	100.00
3-M System	66	83.970	9.713	- .544	- .524	62.00	100.00
Valves	66	84.818	11.762	- .611	- .367	54.00	100.00
Lube System	66	86.545	12.461	-2.823	13.243	18.00	100.00
PE Comp	66	86.621	7.007	- .283	- .059	69.00	100.00
Steam Cycle	66	92.424	6.888	-1.460	3.202	66.00	100.00
Engineering	66	87.879	9.073	- .438	- .775	68.00	100.00
Turbine Theory	66	90.697	9.776	-3.350	16.816	34.00	100.00
Gland Seal	64	91.312	7.527	-1.298	1.955	68.00	100.00
Pump Theory	64	90.187	8.325	- .779	- .366	70.00	100.00
Steam System	66	87.469	12.923	-3.191	15.778	14.00	100.00
Generator	64	90.781	7.238	-1.017	1.373	66.00	100.00
MM Comp	64	85.750	10.234	-2.916	14.118	29.00	100.00
FSG	66	89.997	5.215	- .497	- .313	77.01	98.40
Form 2							
Piping System	306	84.072	9.463	- .842	.903	44.00	100.00
Water System	303	84.264	10.241	- .669	- .119	46.00	100.00
3-M System	297	82.545	9.458	- .894	1.647	40.00	100.00
Valves	294	81.109	11.565	- .606	.250	42.00	100.00
Lube System	293	83.843	9.102	- .673	.507	50.00	100.00
PE Comp	291	84.048	7.211	- .375	.126	59.00	99.00
Steam Cycle	288	89.354	8.132	-1.064	1.017	56.00	100.00
Engineering	287	84.962	9.050	- .911	.939	52.00	100.00
Turbine Theory	285	86.982	7.663	- .774	.180	66.00	100.00
Gland Seal	284	87.993	7.610	- .848	.407	62.00	100.00
Pump Theory	284	86.218	8.977	- .783	.693	54.00	100.00
Steam System	284	85.063	9.688	-1.776	7.538	26.00	100.00
Generator	284	85.944	7.807	- .481	- .148	64.00	100.00
MM Comp	284	82.655	7.002	- .276	- .349	64.00	98.00
FSG	306	85.007	5.350	- .545	2.276	60.50	97.50

set of all test variables in these analyses. Resulting scree tests and factor loadings for the two forms were similar, both indicating a one-factor solution.

Table 73 shows the communalities, factor loadings, and factor score coefficients for Form 1 and Form 2. For both forms, all of the tests loaded

Table 73

Communalities, Factor Loadings and Factor Score Coefficients for MM1 Variables

Variable	Communality		Factor Loadings		Factor Score Coefficients	
	Form 1	Form 2	Form 1	Form 2	Form 1	Form 2
Piping System	.414	.365	.644	.604	.072	.118
Water System	.523	.361	.723	.601	.144	.106
3-M System	.397	.239	.630	.489	.076	.080
Valves	.525	.469	.725	.685	.071	.149
Lube System	.211	.313	.460	.559	.015	.094
PE Comp	.690	.349	.831	.591	.255	.104
Steam Cycle	.322	.332	.568	.576	.081	.101
Engineering	.628	.405	.792	.636	.223	.133
Turbine Theory	.370	.275	.609	.524	.067	.083
Gland Seal	.405	.343	.636	.586	.079	.104
Pump Theory	.417	.297	.646	.545	.057	.093
Steam System	.149	.170	.385	.412	.033	.068
Generator	.310	.243	.557	.493	.073	.078
MM Comp	.378	.511	.614	.715	.082	.176

Note. For Form 1, n = 64. For Form 2, n = 284.

highly on the factor. Factor loadings ranged from .385 to .831 for Form 1 and .412 to .715 for Form 2.

We sought to develop composite variables which would capture essential elements of the criterion variance and also represent meaningful content dimensions useful to the MM school. In order to examine whether a PE section versus an MM section distinction could explain aspects of school performance, we developed a PE Grade composite and an MM Grade composite (see Table 1 for computations of these composites). Since the MM school computed the FSG using a 75 as the minimum score, RGI calculated its own final grade (FSG2) using initial test scores and listed both as composite variables. We used the factor score (Factor1) as an additional composite. Table 74 shows the descriptive statistics for each of the composite variables mentioned above. We placed all

Table 74

Descriptive Statistics for MM1 Composite Variables

Composite	n	Rel[a]	Mean	Std Dev	Skew	Kurtosis	Min	Max
Form 1								
FSG	66		89.997	5.215	-.497	-.313	77.10	98.40
FSG2[b]	64	.903	87.810	6.288	-.485	-.439	74.23	97.10
PE Grade[c]	66	.845	86.376	6.288	-.485	-.439	74.23	97.10
MM Grade[d]	64	.821	89.350	5.983	-.710	-.060	75.14	98.49
Form 2								
FSG	306		85.007	5.350	-.545	2.276	60.50	97.50
FSG2	284	.885	84.749	5.373	.181	-.669	69.91	97.39
PE Grade	291	.819	83.522	6.379	.054	-.338	63.96	97.68
MM Grade	284	.807	85.878	5.262	-.069	-.634	71.71	97.54

Note. For Form 1, n = 64. For Form 2, n = 284.
[a] These are composites based on communality estimates and the procedures described in the text.
[b] FSG2: (PE Grade + MM Grade)/2.
[c] PE Grade: .8 (mean of Piping System, Water System, 3-M System, Valves, and Lube System) + .2(PE Comp).
[d] MM Grade: .8 (mean of Steam Cycle, Engineering, Turbine Theory, Gland Seal, Pump Theory, Steam System, and MM Generator) + .2(MM Comp).

the composite variables on a scale of 0-100 in order to compare them more readily. The sample size varied for the composites depending on the number of tests missing in each case.

Finally, we computed pearson correlation coefficients for the composite variables. Table 75 presents these correlations. For both Form 1 and Form 2, the PE Grade and MM Grade scores correlated greater than .90 with the Factor1 composite variable. Also noted on Form 1 and Form 2, both final school grades (FSG and FG) correlated strongly with Factor 1. Although the MANOVA and MANCOVA tests revealed Form 1 and Form 2 to be significantly different groups, they demonstrated similar patterns of relationships with the other composites. To determine whether the two forms have the same underlying factor, we computed the

Table 75

Correlations Among MM1 Composites and Factors

Composite	Factor1	FSG	FSG2[a]	PE Grade[b]	MM Grade[c]
Factor1	—	.98	.99	.91	.93
FSG	.93	—	.98	.91	.90
FSG2	.98	.92	—	.94	.91
PE Grade	.95	.78	.95	—	.70
MM Grade	.91	.94	.91	.73	—

Note. Coefficients below the diagonal correspond to Form 1 (n = 64). Coefficients above the diagonal correspond to Form 2 (n = 284).
[a] FG: (PE Grade + MM Grade)/2.
[b] PE Grade: .8 (mean of Piping System, Water System, 3-M System, Valves, and Lube System) + .2(PE Comp).
[c] MM Grade: .8 (mean of Steam Cycle, Engineering, Turbine Theory, Gland Seal, Pump Theory, Steam System, and MM Generator) + .2(MM Comp).

congruence coefficient between the factor loadings from each form (Horsuch, 1983, p. 285, Congruence = .99). This indicates that the factor patterns of the two forms are similar. However, the small sample size of Form 1 (n=64), suggests that the results of the Form 1 factor analysis may have low stability.

Recommendations. RGI recommends using the school-calculated FSG.

Machinist's Mate (MM2)

On January 7, 1991, the MM school integrated the Propulsion Engineering Basics (PE) course material into its curriculum. At this time, the school changed the course curriculum and the test content to avoid redundancy. The preceding section (labeled MM1) covers students entering the MM school before the changes of January 7, 1991, when PE and MM course material remained distinct. This section, MM2, addresses students entering the MM school after the instructors integrated the PE and the MM course material (as of January 7, 1991).

Description of Variables. The school determined appropriate item weights for converting each knowledge test grade into a percentage score. See Appendix G for a list of these weights. The school requires a score of 63% or higher to pass each exam. Students who fail a test participate in instructor oral remediation, night study, and retesting. Examinees cannot retest until the next academic day. All students who fail the retest appear before the Academic Review Board. The school then decides upon the student's status. The instructor assigns the minimum passing score to those students who pass the retest, and the school uses that minimum score to compute the final school grade (FSG). Although the school assigns a score of 63 for all successful retests, RGI entered only the initial test scores for each examinee.

The MM school assesses student progress using knowledge tests, comprehensive tests, and quizzes. Table 76 presents these variables and their corresponding descriptions. The instructors divide the curriculum into Phase 1 and Phase 2, roughly representing a focus on PE and MM issues (respectively). Phase 1 includes tests and quizzes up to and including the first comprehensive exam. Phase 2 covers the remaining half of the course. For each student, the school computes a Phase 1 and a Phase 2 grade from a weighted average of the

Table 76

Descriptions of MM2 Variables

Test No.	Description (Name - Type of Test)[a]
204	**Quiz 1**: Main propulsion plant/machinery nomenclature, shipboard watch organization, PQS program, shipboard piping systems, operating principles of piping system components, tracing piping systems, heat exchangers, piping system components, tag-out system (Piping System - Q)
305	**Knowledge Test 1**: Quiz 1 content (Piping System - K)
206	**Quiz 2**: 3-M system & metal fasteners (3-M System - Q)
208	**Quiz 3**: Common hand tools, pipe/tubing & fitting, lubricant, packing/gaskets & insulation, precision measuring (Tools -Q)
309	**Knowledge Test 2**: Content from Quiz 2 and Quiz 3 (3-M & Tools - K)
212	**Quiz 4**: Globe/ball/gate/needle/butterfly/plug-cock/check/relief/sentinel valves, external valve inspection, centrifugal pumps, jet pumps, rotary pumps (Valves - Q)
313	**Knowledge Test 3**: Quiz 4 content plus centrifugal/reciprocating static display pumps (Valves - K)
214	**Quiz 5**: Firemain system, auxiliary machinery cooling water system, waste & oily water systems (Water System -Q)
317	**Knowledge Test 4**: Quiz 5 content plus main drain system, potable water system, low pressure air system, communication devices, single agent system, halon extinguishing system, bearings, gears, couplings, & plastics control (Water System - K)
319	**Comprehensive Knowledge Test 1**: Propulsion Engineering Basics issues - Content from tests 204 to 317 plus introduction to cold iron & cold iron trainer lab (PE Comp - C)
223	**Quiz 6**: Damage control, equipment technical manuals, basic steam cycle, boilers (Steam Cycle - Q)
224	**Quiz 7**: Fuel oil service system (Fuel Oil - Q)
325	**Knowledge Test 5**: Content from Quiz 6 and Quiz 7 plus combustion air (Steam & Fuel - K)
227	**Quiz 8**: Main steam system, auxiliary steam system, heat stress (Steam System - Q)
328	**Knowledge Test 6**: Quiz 8 content plus reduced pressure steam & superheater protection steam (Steam System - K)
230	**Quiz 9**: Main Propulsion engine and main lube oil system (Lube System - Q)
331	**Knowledge Test 7**: Quiz 9 content plus strainer/bearing lab, lube oil purification/transfer system (Lube System - K)
334	**Knowledge Test 8**: Diaphragm control valve, lube oil purifier, gland seal/gland exhaust/sea-water circulating system, main condenser (Gland Seal - K)
235	**Quiz 10**: Main condensate system/main air removal (Condensate - Q)
237	**Quiz 11**: Main feed system, deaerating feed tank, cutaway/spray nozzle lab, steam drains (Feed System - Q)
338	**Knowledge Test 9**: Quiz 10 & 11 content plus auxiliary exhaust/escape steam piping (Cond & Feed - K)
239	**Quiz 12**: Distilling plant (Distilling - Q)
341	**Knowledge Test 10**: Quiz 12 content plus make up/excess/reserve feed, water chemistry, noise awareness, & throttleboard stimulator (Distilling - K)
242	**Quiz 13**: Basic electricity (Electricity - Q)
344	**Knowledge Test 11**: Quiz 13 content plus ship service, turbo generator, electrical distribution, IC alarm (Electricity -K)
144	**Performance Test (oral board comprehensive exam)**: Basic steam cycle (Steam Cycle - P)
349	**Comprehensive Knowledge Test 2**: Machinist's Mate issues - Content from tests 223 to 344 plus Hot plant indoctrination, main propulsion, auxiliary system (MM Comp - C)

[a] Q: Quiz, K: Knowledge, P: Performance, C: Comprehensive.

corresponding test scores (see Appendix G for test weights). The school uses the mean of the two phase grades as the FSG. The school also divides the curriculum into eleven units. Each knowledge test occurs at the end of its corresponding unit. Although quizzes and knowledge tests address the same content areas within each unit, the knowledge tests address the material in more specific terms. All tests and quizzes have a valid range of 0 to 100.

Table 77

Descriptive Statistics for MM2 Variables

Variable	n	Mean	Std Dev	Skew	Kurtosis	Min	Max
Piping System-Q	706	80.167	14.932	- .564	- .315	40.00	100.00
Piping System-K	706	76.926	09.290	- .672	1.110	33.60	098.20
3-M System-Q	705	87.872	11.445	-1.504	5.187	10.00	100.00
Tools-Q	703	84.669	12.743	-1.017	2.122	12.00	100.00
3-M & Tools-K	703	82.646	09.212	- .623	.213	52.90	100.00
Valves-Q	700	82.400	14.401	- .731	.199	20.00	100.00
Valves-K	699	79.520	12.837	- .507	- .433	32.70	100.00
Water System-Q	696	83.250	15.167	-1.233	2.621	12.00	100.00
Water System-K	694	78.304	12.189	- .556	- .152	32.70	100.00
PE Comp-C	692	78.452	10.447	- .513	.284	25.20	100.00
Steam Cycle-Q	690	77.638	17.302	- .680	.124	20.00	100.00
Fuel Oil-Q	689	81.480	15.206	- .682	.016	20.00	100.00
Steam & Fuel-K	688	74.628	13.848	- .420	- .285	25.20	100.00
Steam System-Q	685	92.321	09.942	-1.463	2.148	50.00	100.00
Steam System-K	685	74.586	13.429	- .252	- .404	28.60	100.00
Lube System-Q	683	77.088	17.897	- .683	.129	10.00	100.00
Lube System-K	682	75.835	11.874	- .510	.812	14.50	100.00
Gland Seal-K	680	75.991	13.391	- .463	- .146	28.40	100.00
Condensate-Q	680	80.174	16.586	- .751	.182	12.00	100.00
Feed System-Q	676	77.707	17.552	- .778	.292	20.00	100.00
Cond & Feed-K	678	71.215	13.185	- .292	- .108	19.50	100.00
Distilling-Q	673	81.070	16.194	- .962	.657	20.00	100.00
Distilling-K	669	75.698	12.463	- .379	- .112	25.80	100.00
Electricity-Q	667	87.570	12.761	-1.157	1.413	30.00	100.00
Electricity-K	665	79.193	11.911	- .473	- .353	37.20	100.00
Steam Cycle-P	604	100.000	100.000	.	.	100.00	100.00
MM Comp-C	662	74.558	09.749	- .116	- .365	47.50	100.00

Sample. The initial sample consisted of 710 students who began training between January and October 1991. We excluded students who did not take every test from some of the analyses. Consequently, our final sample contained 659 cases.

Results and Discussion. RGI computed descriptive statistics for each of the test variables. Table 77 presents these statistics for all variables. The table lists an n of 604 cases for the performance test at the end of Phase 2 (Steam Cycle-P). Because 106 students were missing data for this test, it was not included in some of the analyses. However, the MM school includes this test when calculating the Phase 2 grade and the FSG. Consequently, we maximized our number of cases when computing Phase 2 and FSG scores by prorating scores on the performance test for the 106 cases. This involved taking the average of their available scores and weighting the remaining tests appropriately.

Next, we conducted a factor analysis on the set of all test variables. The scree test and the factor loadings indicated one factor. Table 78 shows the communalities, factor loadings, and factor score coefficients for each of the variables. Factor loadings ranged from .256 to .673.

We sought to develop composite variables which would capture essential elements of the criterion variance and also represent meaningful content dimensions useful to the MM school. Since the school divides the curriculum into phases and computes grades for each phase, we used the school's weighting system to compute Phase 1 and Phase 2 grades. We also created composites based on test type by averaging all quizzes for one composite and all knowledge tests for another. Since the MM school computes the FSG using 63 as the minimum score, RGI calculated its own final grade (FSG2) using initial test scores and employed both as composite variables. We used the factor score (Factor 1) as an additional

composite. Table 79 presents descriptive statistics for each of the composite variables mentioned above. We placed all of the composites on a 0-100 scale in order to facilitate comparing them. The sample size varied for the composite variables depending on the number of tests missing for each case.

Table 78

Communalities, Factor Loadings and Factor Score Coefficients for MM2 Variables

Variable	Communality	Factor Loadings	Factor Score Coefficients
Piping System-Q	.195	.442	.046
Piping System-K	.397	.630	.093
3-M System-Q	.066	.256	.026
Tools-Q	.120	.346	.036
3-M & Tools-K	.319	.565	.076
Valves-Q	.152	.390	.042
Valves-K	.343	.586	.073
Water System-Q	.103	.321	.033
Water System-K	.389	.624	.091
PE Comp-C	.344	.587	.083
Steam Cycle-Q	.211	.460	.050
Fuel Oil-Q	.221	.470	.055
Steam & Fuel-K	.453	.673	.109
Steam System-Q	.107	.327	.034
Steam System-K	.387	.622	.085
Lube System-Q	.159	.399	.051
Lube System-K	.397	.630	.092
Gland Seal-K	.330	.574	.074
Condensate-Q	.225	.474	.058
Feed System-Q	.105	.324	.034
Cond & Feed-K	.428	.654	.098
Distilling-Q	.244	.494	.060
Distilling-K	.253	.503	.058
Electricity-Q	.180	.425	.046
Electricity-K	.357	.597	.081
MM Comp-C	.409	.639	.092

Note. N = 659.

Table 79

Descriptive Statistics for MM2 Composite Variables

Composite	n	Rel[a]	Mean	Std Dev	Skew	Kurtosis	Min	Max
FSG	707	.876	79.531	6.583	-.210	1.730	40.30	96.80
FSG2[b]	659	N/A	78.415	7.047	.105	-.375	57.16	96.77
KTest[c]	661	.885	77.010	7.585	.130	-.366	55.94	96.95
Quiz[d]	664	.739	82.815	7.171	-.360	-.207	60.77	99.23
Phase1[e]	690	.742	79.600	7.572	-.137	.467	57.10	96.25
Phase2[f]	660	.837	76.933	7.822	.105	.435	54.93	97.28

a These are composites based on communality estimates and the procedures described in the text.
b FSG2: Final School Grade computed using initial scores.
c Ktests: Average of all knowledge test scores.
d Quiz: Average of all quiz scores.
e Phase1: See Appendix _ for computation.
f Phase2: See Appendix _ for computation.

Finally, we computed Pearson correlation coefficients for the composites. Results revealed high zero-order correlations between all composite variables. Table 80 presents these correlations.

Recommendations. RGI recommends using the school-calculated FSG.

Table 80

Correlations Among MM2 Composites and Factors

Comp	Fac1	FSG	FSG2[a]	Ktest[b]	Quiz[c]	Phase1[d]
FSG	.97					
FSG2	.98	.99				
Ktest	.98	.97	.99			
Quiz	.86	.77	.76	.74		
Phase1	.88	.93	.92	.87	.70	
Phase2[e]	.94	.91	.93	.96	.72	.72

[a]FSG2: Final School Grade computed using initial test scores.
[b]Ktests: Average of all knowledge test scores.
[c]Quiz: Average of all quiz scores.
[d]Phase1: See Appendix for computation.
[e]Phase2: See Appendix for computation.

Operations Specialist (OS)

Description of Variables. The OS school evaluates students using written, performance, and blitz tests. The school modified the test forms in August 1990. Test Form A refers to the previous test form, and Test Form B refers to the current test form in use. Although changes occurred in the sequence and the number of tests, the test content did not change. In some cases, the school consolidated the performance and written tests into one test. Notes throughout the variable descriptions indicate the occurrence of a sequence change or a consolidation of test material. Where sequence changes occurred between test forms, we placed the form associated with each test name in parentheses (e.g., Form B only). We designated written test scores as (W), performance test scores as (P), and tests consisting of a performance test and a written test as (P/W). Table 81 provides the description and sequence of the Form A and Form B OS tests.

The school sets the minimum passing score for each test at 70. For students passing the retest, the OS school assigns a score of 70 to be included in the student's final school grade (FSG). We entered only the students' initial scores into the database.

The FSG currently consists of a simple average of all performance, written, and performance/written exams. The school did include blitzes (quizzes) in the final average until May 1991. Instructors now use blitzes only as a tool to evaluate the weekly progress of the students. The school decided that including the blitzes in the FSG conflicted with the purpose of the blitzes, identifying problem areas where students need additional training. We decided not to include the blitz scores in the analyses for three reasons. First, including both tests and blitzes in the analyses causes multicollinearity problems because they cover

Table B1

Descriptions of OS Variables

Variables	Description (Abbreviated Name - Type of Test[a])
Security/Bearings	Tests knowledge on procedures for handling classified material and procedures for converting True, Relative, and Reciprocal Bearings and Target Angles. (Security - W)
Basic Maneuvering Board	Tests knowledge and ability to solve relative motion problems on a Maneuvering Board for either ownship or contact course, speed, and closest point of approach. (Basic Man Bd. - P/W)
Advanced Maneuvering Board 1	Tests knowledge and ability to determine a revised closest point of approach and to compute ownship course change to avoid a contact by a specified distance. (Adv Man Bd1 - P)
(The school flip-flopped the sequence of the following two tests on the two forms.)	
Internal Communications	Tests knowledge and ability to communicate with another station on sound powered phone circuits. (Test Form A only) (Int. Comm. - P/W)
Maneuvering Board 2	Tests knowledge and ability to compute on ownship's maneuver to change its assigned station. Tests knowledge and ability to use the maneuvering board to determine the apparent, relative, and true direction and speed of the wind. (Test Form A only) (Man. Board2 - P)
Advanced Manueuvering Board 2	Tests knowledge and ability to compute on ownship's maneuver to change its assigned station.Tests knowledge and ability to use the maneuvering board to determine the apparent, relative, and true direction and speed of the wind. (Test Form B only) (Adv Man Bd2 - P)
Internal Communication/ 3 Minute Rule	Tests knowledge and ability to communicate with another station on sound powered phone circuits and use the 3 minute rule to solve for speed. (Test Form B only) (Int. Comm/3 Min - P/W)
Publications/Logs	Tests knowledge and ability to maintain a Combat Information Center (CIC) Log using proper abbreviations. Tests knowledge and ability to use proper CIC publications. (Pubs/Logs - P/W)
(The school consolidated the content of the following two Form B tests into other version A tests. The school included the content of Maneuvering Board 3 into the Advanced Maneuvering Board 2 test, and the content of the 3 minute rule with the Internal Communication test.)	
Maneuvering Board 3	Tests knowledge and ability to compute on ownship's maneuver to change its assigned station and use the maneuvering board to determine the apparent, relative, and true direction/speed of wind. (Test Form A only) (Manuv. Board3 - P)
3 Minute Rule/Symbols	Tests knowledge and ability to use 3 minute rule to solve for speed. (Test Form A only) (3Min/Symbols - W)
Signal Book Formation	Tests knowledge and ability to encode and decode given signals, and use Signal Book to put ships in formation. (Signal Bk - P)
Cartesian Grid	Tests knowledge and ability to plot contacts on a Cartesian Grid. (Cart Grid - P)
External Communication	Tests knowledge and ability to communicate with another ship on a radiotelephone circuit. (Ext. Comm. P/W)
(The school flip-flopped the sequence of the following two tests on the two forms.)	
Air Plotter	Tests knowledge and ability to plot contacts with amplifying information on an Air Summary Board. (Test Form A) (Air Plot - P/W)

[a]Key to type of test: W-Written; P-Performance; P/W-Performance/Written

Table 61 (Continued)

Variable	Description (Abbreviated Name - Type of Test[a])
Surface Summary	Tests knowledge and ability to plot contacts with amplifying information on a Surface Summary Board. (Test Form A only) (Surf. Summ. - P)
Surface Summary	Tests knowledge and ability to plot contacts with amplifying information on a Surface Summary Board. (Test Form B only) (Surf. Summ. - P)
Air Plotter	Tests knowledge and ability to plot contacts with amplifying information on an Air Summary Board. (Test Form B only) (Air Plot - P/W)
Dead Reckoning Tracer	Tests knowledge and ability to perform duties of a Dead Reckoning Tracer operator using DRT plotting procedures, symbology and abbreviations. Tests knowledge and ability to compute course and speed on two surface contacts. (Dead Rec. - P)
Charts Sea & Anchor	Tests knowledge of Chart Correction Card System and purpose of the Notice to Mariners. Tests the ability to locate charts by name and number for transit situations. (Charts - W)
Coastal Navigation	Tests knowledge and ability to perform duties of the Navigation Plotter, to plot coastal navigation fixes, to plot dead reckoning positions along intended track, to compute course and speed made good between two navigation fixes, to compute set and drift between a dead reckoning position and a navigation fix, to compute and plot an estimated position, and to plot an operating area and to record navigational fix data. (Coast Nav. - P)
67/25/25G/ Rules of the Road (ROR)	Tests knowledge and ability to perform duties of Radar Plan Position Indicator Operator, detect, plot, and report all surface or air contacts, distinguishing them from weather, land, and sea return. Tests ability to obtain CPA (closest point of approach) bearing range and time, and course and speed on three surface contacts. Tests knowledge of the SPS/67 Radar Set Control. Tests knowledge of an overtaking, crossing, and meeting situation, and the purpose and types of navigation lights. (Rules Rd.-W)
SPA-25F PT	Tests ability to compute revised CPA (bearing, range, and time), to solve for CPA for each contact, and to perform duties of Radar Scope Operator, detect, plot and report all surface and air contacts. (Radar Scope Op - P)
(The school consolidated the following Air and Surface NTDS WTN tests and the Air and Surface NTDS PT tests from Form B into a single written test and a single performance test, respectively, on Form A.)	
Air NTDS	Tests knowledge of the duties of Naval Tactical Data System Input Console (NTDS) Operator in the Air Tracker mode of operation. (Test Form A) (Air Tracker - W)
Air NTDS	Tests ability to perform duties of NTDS Input Console Operator in the Air Tracker mode of operation. (Test Form A only) (Air Tracker - P)
Surface NTDS	Tests ability to perform duties of NTDS Input Console Operator in the Surface Tracker mode of operation. (Test Form A only) (Surface Tracker - P)
Surface NTDS	Tests knowledge of the duties of NTDS Input Console Operator in the Surface Tracker mode of operation. (Test Form A only) (Surface Tracker - W)
NTDS	Tests knowledge of the duties of NTDS Input Console Operator in the Surface Tracker and Air Tracker mode of operation. (Test Form B only) (Air/Surf Tracker - W)
NTDS PT	Tests ability to perform duties of NTDS Input Console Operator in the Surface Tracker and Air Tracker mode of operation. (Test Form B only) (Air/Surf Tracker - P)

[a]Key to type of test: W-Written; P-Performance; P/W-Performance/Written

the same material as the tests. Second, the motivational impact of a blitz differs from a test because students realize their blitz performance will not affect their FSG. Finally, the school ultimately excluded them from performance assessment and used them more as a training tool.

Sample. The total sample consisted of 802 students. The school used the older Form A for 153 of these students. Of these 153 cases, 109 had completed all Form A tests. The remaining 649 students completed Form B. We received complete data for 530 of these cases. We excluded cases with missing data from some of the analyses.

Results and Discussion. We began by testing the two groups of students for differences due to the change in curriculum. We conducted a multivariate analysis of variance (MANOVA) to test the correlation matrices of the test scores. A test for homogeneity of covariance matrices revealed that the two forms had significantly different covariance matrices ($F=2.152$, $p<.001$). The test means also differed significantly across the two forms ($F=11.553$ $p<.001$).

To test whether ability accounted for these differences between the two groups of students, RGI conducted a multivariate analysis of covariance (MANCOVA) using the student's pre-enlistment ASVAB scores as covariates. After partialling out the variance due to ASVAB scores, test for homogeneity of covariance matrices revealed different matrices for the two forms ($F=1.53$, $p<.001$). Test means also differed across the two forms after controlling for ASVAB scores ($F=11.985$, $p<.001$). Univariate F-tests indicated that 8 of the 18 variables differed between forms at the $p<.05$ level. These results suggest that the noted difference between the two groups is due to something other than differences in ability. Based on these findings, we analyzed each group separately.

To further evaluate the conclusion of differences between forms, we computed effect sizes as measures of the practical significance of the difference between the unadjusted means across forms. Cohen and Cohen (1977) say that .2 represents a small effect size, .5 is medium, and .8 is large. For the total of 18 comparisons among the OS forms, we found 10 within the range of .00 - .19, 6 within the range of .20 - .49, 1 within the range of .5 - .79, and 1 greater than .80. These results show that 89% of the effect sizes fall below a value of .50. Thus, while the MANOVA tests indicate that the forms differ from one another in terms of statistical significance, the effect sizes suggest small magnitudes of the differences, in terms of practical significance.

We computed descriptive statistics for each of the test forms separately. Table 82 presents these statistics for Form A and Form B.

After viewing score distributions, we conducted a factor analysis on each form separately. In Form A the scree test and factor loadings indicated a one factor solution. The Form B scree test and the factor loadings indicated two factors. Based on the way variables loaded on the two Form B factors, we labeled the first factor Communication and the second factor Navigation/Plotting (Nav/Plot). Table 83 lists the communalities, factor loadings, and factor score coefficients for each of the Form A and the Form B variables.

Next, we created various composite variables for Form A and Form B. In order to examine whether a communication versus navigation/plotting test content distinction could explain aspects of school performance, we created the composite variables of "Communication" and "Navigation/Plotting" for Form B. We computed these by taking an average of those tests with a description

Table 82

Descriptive Statistics for OS Variables

Variable	n	Mean	Std Dev	Skew	Kurtosis	Min	Max
Form A							
Security - W	151	89.457	9.792	-1.613	3.157	48.00	100.00
Basic Man Bd. - P/W	153	89.216	8.299	- .975	.520	62.50	100.00
Adv Man Bd1 - P	153	83.327	12.248	-1.203	1.671	37.50	100.00
Man Board2 - P	153	84.072	12.690	- .996	1.141	40.00	100.00
Man Board3 - P	153	88.556	11.822	-1.011	.381	50.00	100.00
Int. Comm - P/W	153	91.405	6.974	-1.253	2.105	63.00	100.00
3Min/Symbols - P/W	153	93.575	7.849	-1.976	5.732	52.00	100.00
Pubs/Logs - P/W	153	89.627	6.766	- .809	.325	70.00	100.00
Signal Bk - P	153	86.993	10.344	-1.048	1.233	48.00	100.00
Cart Grid - P	153	93.536	7.289	-2.367	7.804	48.00	100.00
Ext Comm. - P/W	153	88.784	6.849	-1.017	1.784	59.00	100.00
Surf Summ. A - P	153	92.984	7.911	-3.350	15.428	44.00	100.00
Air Plot A - P/W	153	90.748	6.965	-1.367	1.625	70.00	100.00
Dead Rec. - P	153	88.016	8.535	-1.085	1.392	54.00	100.00
Charts - W	153	85.978	8.523	- .425	- .566	64.00	100.00
Coast Nav. - P	153	86.418	10.170	- .829	.512	52.00	100.00
Rules Rd. - W	153	84.542	8.333	- .526	.193	55.00	100.00
Radar Scope Op - P	153	98.804	1.950	-2.050	4.959	90.00	100.00
Surface Tracker - W	150	82.899	9.542	- .287	.288	55.00	100.00
Surface Tracker - P	150	92.968	6.841	-1.299	1.737	70.00	100.00
Air Tracker - W	115	81.967	8.717	- .045	- .700	58.00	100.00
Air Tracker - P	114	94.513	11.114	-3.053	12.090	27.50	100.00
Form B							
Security - W	649	85.637	9.566	- .872	1.349	37.50	100.00
Basic Man Bd. - P/W	649	85.505	11.852	- .934	.925	36.00	100.00
Adv Man Bd1 - P	649	81.715	13.811	-1.154	1.854	12.00	100.00
Adv Man Bd2 - P	649	89.445	10.865	-1.461	2.675	36.00	100.00
Int. Comm/3 Min - P/W	649	92.242	5.618	- .813	.456	70.00	100.00
Pubs/Logs - P/W	649	89.675	7.199	- .933	1.003	57.00	100.00
Signal Bk - P	649	83.324	11.034	- .835	.875	34.00	100.00
Cart Grid - P	649	94.018	7.013	-2.237	7.807	41.50	100.00
Ext Comm. - P/W	649	93.076	5.884	-1.214	1.930	62.00	100.00
Surf Summ B - P	649	91.444	7.766	-1.140	.845	60.50	100.00
Air Plot B - P	646	90.457	7.007	-1.368	2.255	58.00	100.00
Dead Rec. - P	648	89.746	7.746	-1.099	.988	59.50	100.00
Charts - W	647	85.146	9.477	- .886	1.037	45.00	100.00
Coast Nav. - P	643	87.409	11.177	-1.440	2.682	38.00	100.00
Rules Rd. - W	643	83.063	8.986	- .219	- .446	55.00	100.00
Radar Scope Op - P	643	98.590	3.472	-4.977	36.627	60.00	100.00
Air/Surf Tracker - W	596	85.702	7.520	- .465	.471	48.20	100.00
Air/Surf Tracker - P	548	87.847	10.212	-1.284	2.567	36.80	100.00

Table 53

Communalities, Factor Loadings and Factor Score Coefficients for OS Variables

Form A Variable	Communality	Factor Loadings	Factor Score Coefficients
Security - W	.232	.482	.082
Basic Manuv. Bd - P/W	.473	.687	.181
Adv. Man Bd1 -P	.220	.469	.072
Manuv. Bd2 - P	.304	.551	.100
Manuv. Bd3 - P	.128	.358	.050
Int Comm - P/W	.358	.599	.101
3Min Rule/Sym - P/W	.181	.425	.069
Pubs/Logs - P/W	.381	.617	.144
Signal Bk - P	.198	.445	.060
Cart Grid - P	.253	.503	.086
Ext. Comm - P/W	.256	.506	.079
Surf Summ - P	.212	.461	.072
Air Plot - P/W	.317	.564	.130
Dead Rec. - P	.342	.584	.106
Charts - W	.179	.424	.072
Coast Nav. - P	.203	.450	.069
Rules Rd. - W	.178	.422	.064
Radar Scope Op - P	.017	.132	.019
Surf Tracker - W	.085	.292	.038
Surf Tracker - P	.040	.199	.021
Air Tracker - W	.246	.495	.075
Air Tracker - P	.005	.071	.002

		Factor Loadings		Factor Score Coefficients	
Form B Variable	Communality	Factor 1: Communication	Factor 2: Nav/Plot	Factor 1: Communication	Factor 2: Nav/Plot
Security - W	.365	.543	.264	.147	.006
Basic Man Bd. - P/W	.201	.289	.343	.032	.079
Adv. Man Bd1 -P	.248	.310	.390	.030	.095
Adv. Man BD2 - P	.130	.263	.248	.034	.044
Int Comm/3 Min - P/W	.437	.595	.287	.188	.004
Pubs/Logs - P/W	.309	.508	.226	.139	-.004
Signal Bk - P	.326	.452	.350	.096	.063
Cart Grid - P	.325	.224	.524	-.024	.183
Ext. Comm - P/W	.229	.433	.201	.103	-.002
Surf Summ - P	.390	.076	.620	-.110	.284
Air Plot - P/W	.439	.070	.659	-.133	.336
Dead Rec. - P	.280	.240	.471	-.006	.154
Charts - W	.468	.662	.171	.263	-.077
Coast Nav. - P	.259	.369	.351	.055	.084
Rules Rd. - W	.308	.552	.055	.185	-.085
Radar Scope Op - P	.061	.103	.224	-.009	.057
Air/Surf Tracker - W	.330	.557	.141	.181	-.053
Air/Surf Tracker - P	.105	.167	.277	.007	.062

Note. Form A; $n = 109$, Form B; $n = 471$

related to the content of the variable. Additional Form B composites included the Sum1 and Sum2 variables which took a simple average of all the tests that loaded .30 or above on either Factor 1 or Factor 2, respectively. We also used the Form B factor scores, Factor1 and Factor2, as composite variables. For Form A, we created a Sum1 composite variable which took a simple average of all tests that loaded .30 or above on Factor 1 and also used the Form A factor score, Factor1, as a composite variable. For both Form A and Form B, we combined all written tests, all performance tests, and all performance/written tests separately to determine whether or not the type of test administered could explain school performance. Because the OS school splits the training into two parts, we created two phase variables for both forms based on this separation. The first phase includes all tests up to and including the Air Plot test. The second phase consists of the remaining tests. Because the OS school computes the FSG using a 70 as the minimum score, we calculated our own Final School Grade (FSG2) using initial test scores, and listed both as composite variables for both forms. Table 84 lists the descriptive statistics for each of the composite variables listed above. The n varied for the composite variables depending on the number of tests missing for each case.

Finally we computed Pearson correlation coefficients for the composite variables. Tables 85 and 86 present the intercorrelations between all composite variables for Forms A and B, respectively. Notice that FSG and FSG2 correlated .99 showing no support for using initial test scores to compute FSG. For Form B, these results also show that FSG correlates highly with Communication (.90) and Navigation/Plotting (.91), Performance (.91) and Phase1 (.96).

Table 84

Descriptive Statistics for OS Composite Variables

Composite[a]	n	Rel[a]	Mean	Std Dev	Skew	Kurtosis	Min	Max
Form A								
Sum1[b]	113	.86	87.961	4.912	-.730	.526	73.50	98.36
FSG	150	N/A	88.043	4.296	-.500	.074	75.67	97.31
FSG2[c]	109	.85	88.761	4.313	-.605	.112	77.02	97.48
Writ[d]	110	.54	84.891	5.444	-.307	-.356	71.00	97.20
Perf[e]	114	.68	89.850	4.844	-.894	.486	76.41	97.73
P/W[f]	153	.69	90.559	4.860	-.888	.577	74.67	99.42
Phase1[g]	151	.83	89.387	5.188	-.883	.761	73.73	99.42
Phase2[h]	111	.58	88.380	4.064	-.218	-.676	78.50	96.39
Form B								
Sum1[i]	587	.82	86.647	5.585	-.387	-.177	68.23	99.75
Sum2[j]	639	.77	87.878	5.858	-.620	.081	69.44	99.81
FSG	711	N/A	88.428	4.583	-.420	-.190	75.59	99.20
FSG2[k]	530	.85	88.513	4.606	-.346	-.435	75.98	99.21
Comm[l]	639	.77	87.422	5.523	-.417	-.075	66.44	99.69
Plot[m]	633	.74	89.092	4.918	-.534	-.025	72.75	99.05
Writ[n]	589	.79	84.802	6.532	-.373	.240	59.27	99.65
Perf[o]	540	.71	89.226	5.213	-.613	-.087	71.53	99.33
Perf/Writ[p]	646	.68	90.165	4.851	-.571	.173	71.70	100.00
Phase1[q]	646	.81	88.745	5.057	-.440	-.261	73.41	99.73
Phase2[r]	533	.68	88.227	5.004	-.458	-.088	72.94	98.79

[a]These are composites based on communality estimates and the procedures described in the text.
[b]Sum1: Average of Security, Basic Man Bd, adv Man Bd1, Man Board2, Man Board 3e, Int Comm, 3Min/Symbols, Pubs/Logs, Signal Bk, Cart Grid, Ext Comm, Surf Summ, Air Plot, Dead Rec, Charts, Coas, Rules Rd, Air Tracker - W.
[c]FSG2: Final School Grade using initial test scores.
[d]Writ: Average of all written tests.
[e]Perf: Average of all performance tests.
[f]Perf/Writ: Average of all performance/written tests.
[g]Phase1: Average of tests Security to Air Plot.
[h]Phase2: Average of tests Dead Rec to Air Tracker - P.
[i]Sum1: Average of tests Security, Adv Man Bd1, Int Comm/3Min, Pubs/Logs, Signal Bk, Ext Comm, Charts, Coast Nav, Rules Rd, Air/Surf Tracker.
[j]Sum2: Average of tests Basic Man. Bd, Adv. Man Bd1, Signal Bk, Cart Grid, Surf Summ, Air Plot, Dear Rec, Coast Nav.
[k]FSG2: Final School Grade using initial test scores.
[l]Comm: Average of all tests associated with Communication (Security, Int. Comm/3M, Pubs/Logs, Signal Bk., Ext. Comm., Charts.
[m]Plot: Average of all tests associated with Plotting (Cart. Grid, Surf Summ, Air Plot, Dead Rec, Coast Nav, Rules Rd, Radar Scope Op, Basic Man Bd, Adv. Man Bd1, Adv. Man Bd2.
[n]Writ: Average of all written tests.
[o]Perf: Average of all performance tests.
[p]Perf/Writ: Average of performance/written tests.
[q]Phase1: Average of tests Security - Air Plot.
[r]Phase2: Average of tests Dead Rec - Air/Surf Tracker-P.

Table 85

Correlations Among OS Composites and Factors - Form A

Comp	Fac1	Sum1[a]	FSG	FSG2[b]	Writ[c]	Perf[d]	P/W[e]	Ph1[f]	Ph2[g]
Fac1	—								
Sum1	.99	—							
FSG	.97	.96	—						
FSG2	.98	.98	.99	—					
Writ	.75	.75	.79	.77	—				
Perf	.86	.89	.89	.92	.52	—			
P/W	.92	.88	.87	.86	.61	.67	—		
Ph1	.95	.97	.94	.95	.65	.88	.88	—	
Ph2[k]	.78	.77	.82	.83	.79	.75	.60	.62	—

Note. n = 109

[a]Sum1: Average of tests Security, Adv Man Bd1, Int Comm/3Min, Pubs/Logs, Signal Bk, Ext Comm, Charts, Coast Nav, Rules Rd, Air/Surf Tracker

[b]FSG2: Final School Grade using initial test scores

[c]Writ: Average of tests Secur, Basic Man Bd, Int Comm/3 Min, Pubs/Logs, Ext Comm., Air Plot, Charts, Rules Rd., Air/Surf Tracker -P, Air/Surface Tracker-W

[d]Perf: Average of Adv Man Bd1, Adv Man Bd2, Signal Bk., Cart Grid., Surf Summ., Dead Rec., Coast Nav., Radar Scope Op, Air/Surf Tracker - P

[e]P/W: Average of Basic Man Bd, Int. Comm/3M, Pubs/Logs, Ext. Comm., Air Plot

[f]Ph1: Average of tests Security - Air Plot

[g]Ph2: Average of tests Dead Rec - Air/Surf Tracker-P

Table 86

Correlations Among OS Composites and Factors - Form B

Comp	Fac1	Fac2	Sum1[a]	Sum2[b]	FSG	FSG2[c]	Comm[d]	Plot[e]	Writ[f]	Perf[g]	P/W[h]	Ph1[i]
Fac2	.21											
Sum1	.90	.52										
Sum2	.53	.86	.80									
FSG	.78	.73	.92	.89								
FSG2	.79	.74	.93	.91	.99							
Comm	.93	.46	.96	.74	.90	.90						
Plot	.57	.84	.80	.95	.91	.93	.73					
Writ	.92	.29	.86	.52	.77	.78	.87	.59				
Perf	.56	.82	.81	.93	.91	.92	.74	.93	.57			
P/W	.63	.65	.72	.76	.80	.81	.72	.75	.52	.62		
Ph1	.69	.79	.87	.91	.96	.95	.82	.91	.66	.88	.85	
Ph2[k]	.78	.51	.84	.70	.85	.86	.83	.75	.81	.80	.56	.66

Note. n = 471

[a]Sum1: Average of tests Security, Adv Man Bd1, Int Comm/3Min, Pubs/Logs, Signal Bk, Ext Comm, Charts, Coast Nav, Rules Rd, Air/Surf Tracker

[b]Sum2: Average of tests Basic Man. Bd, Adv. Man Bd1, Signal Bk, Cart Grid, Surf Summ, Air Plot, Dear Rec, Coast Nav.

[c]FSG2: Final School Grade using initial test scores

[d]Comm: Average of all tests associated with Communication (Security, Int. Comm/3M, Pubs/Logs, Signal Bk., Ext. Comm., Charts

[e]Plot: Average of all tests associated with Plotting (Cart. Grid, Surf Summ, Air Plot, Dead Rec, Coast Nav. Rules Rd, Radar Scope Op, Basic Man Bd, Adv. Man Bd1, Adv. Man Bd2

[f]Writ: Average of tests Secur, Basic Man Bd, Int Comm/3 Min, Pubs/Logs, Ext Comm., Air Plot, Charts, Rules Rd., Air/Surf Tracker -P, Air/Surface Tracker-W

[g]Perf: Average of Adv Man Bd1, Adv Man Bd2, Signal Bk., Cart Grid., Surf Summ., Dead Rec., Coast Nav., Radar Scope Op, Air/Surf Tracker - P

[h]Perf/Writ: Average of Basic Man Bd, Int. Comm/3M, Pubs/Logs, Ext. Comm., Air Plot

[i]Phase1: Average of tests Security - Air Plot

[j]Phase2: Average of tests Dead Rec - Air/Surf Tracker-P

The strongest correlation with Factor1 of Form A occurs with Sum1 (.99), followed closely by FSG (.97). Sum1 and FSG also correlate highly (.96).

The strongest correlation with Factor1 of Form B occurs with Communication (.93), followed closely by Written (.92) and Sum1 (.90). Sum1 also correlates highly with Communication (.96). The strongest correlation for Factor2 of Form B occurs with Sum2 (.86), followed closely by Navigation/Plotting (.84) and Performance (.82). Sum2 correlated highly with both Navigation/Plotting (.95) and Performance (.93).

Recommendation. Use FSG for Form A and Form B. For Form B only, also use the average of all "Communication" tests and the average of all "Navigation/Plotting" tests.

Radioman (RM)

Description of Variables. The Radioman (RM) school assesses student performance by progress tests and within-course comprehensive tests. These include criterion-referenced knowledge and performance tests. The RM school consists of 11 weeks of instruction. Student action code reflects graduation status or why a student was dropped (see Appendix B).

All test scores in the database represent initial scores only. Knowledge tests require a minimum score of 80 to pass. The school allows students up to 2 retests; however, the school assigns a score of 80 for all successful retests. Performance tests require a minimum score of 100 to pass. Comprehensive tests require a minimum score of 75 to pass. The school allows students up to 2 retests on the comprehensive tests and then assigns a score of 75 for all successful retests. Test #003 (the Ace Lab) in the former curriculum requires a minimum score of 70 to pass. The school allows students up to 2 retests and then assigns a score of 70 for successful Ace Lab retests. If a student fails a 2nd retest, the Academic Review Board (ARB) determines the student's status. RGI entered the number of retests for each test module into the database in addition to the initial test score.

The RM school implemented a new course curriculum in October 1990. The curriculum variable indicates which curriculum the student received. Both the old and the new curricula have 3 phases, and each phase has a comprehensive final test. Each test module has 3 versions.

Table 87 identifies the tests by number and describes their content for both the former and the present curricula. The school implemented several changes from the old curriculum to the new curriculum. In Phase I, the typing

Table 5[a]
RM Variables in the Former and Present Curricula

Var. No.	Description (Name - Type of Test[a])
	Former Curriculum
	Phase I
210	knowledge test covering Communication Organization (Communication Organization - K)
330	knowledge test covering Security (Security - K)
440	knowledge test covering Message Format (Parts, Components, Elements) (Message Format - K)
441	knowledge test covering Basic Message Format (Basic Message Format - K)
442	End of Phase I Comprehensive test (Phase I Comprehensive)
	Phase II
550	knowledge test covering Radiowave Propagation and Modes of Operation (Radiowave Propagation - K)
610	knowledge test covering Safety (Safety - K)
510	knowledge test covering Basic Communications Equipment (Basic Communications Equipment - K)
760	performance test covering Communication System Construction (Communication System Construction - P)
511	performance test covering Planned Maintenance Sub-system (PMS) (Planned Maintenance Sub-system - P)
025	knowledge test covering Theater Nuclear Warfare (Theater Nuclear Warfare - K)
133	end of Phase II Comprehensive test (Phase II Comprehensive)
	Phase III
110	performance test covering Message Processing Inrouter/File Clerk (Message Processing Inrouter - P)
131	knowledge test covering NAVMACS Initialization (NAVMACS Initialization - K)
132	performance test covering NAVMACS BCST Operation (NAVMACS BCST Operation - P)
830	knowledge test covering Message Processing Outrouter (Message Processing Outrouter - K)
930	knowledge test covering RTTY Circuit Operations, Call Signs, Prosigns, and Operating Signals (RTTY Circuit Operations - K)
123	knowledge test covering Circuit Operations and Radiotelephone (Circuit Operations - K)
002	performance test covering Circuit Operations (Circuit Operations - P)
464	knowledge test covering Tapecutting Corrections (Tapecutting Corrections - K)
470	performance test covering UGC-6 Operator Maintenance (UGC-6 Operator Maintenance - P)
026	end of Phase III Comprehensive test (Phase III Comprehensive)
003	Ace Lab (Ace Lab - P)
	Present Curriculum
	Phase I
210	knowledge test covering Communication Organization (Communication Organization - K)
330	knowledge test covering Security (Security - K)
441	knowledge test covering Basic Message Format (Basic Message Format - K)
442	End of Phase I Comprehensive test (Phase I Comprehensive - K)
	Phase II
550	knowledge test covering Radiowave Propagation and Modes of Operation (Radiowave Propagation - K)
610	knowledge test covering Safety (Safety - K)
510	knowledge test covering Basic Communications Equipment (Basic Communications Equipment - K)
760	performance test covering Communication System Construction (Communication System Construction - P)
511	performance test covering Planned Maintenance Sub-system (PMS) (Planned Maintenance Sub-system - P)
025	knowledge test covering Theater Nuclear Warfare (Theater Nuclear Warfare - K)
133	end of Phase II Comprehensive test (Phase II Comprehensive)
	Phase III
110	performance test covering Message Processing Inrouter/File Clerk (Message Processing Inrouter - P)
131	knowledge test covering NAVMACS Initialization (NAVMACS Initialization - K)
830	knowledge test covering Message Processing Outrouter (Message Processing Outrouter - K)
930	knowledge test covering RTTY Circuit Operations, Call Signs, Prosigns, and Operating Signals (RTTY Circuit Operations - K)
123	knowledge test covering Circuit Operations and Radiotelephone (Circuit Operations - K)
002	performance test covering Circuit Operations (Circuit Operations - P)
464	knowledge test covering Tapecutting Corrections (Tapecutting Corrections - K)
470	performance test covering UGC-6 Operator Maintenance (UGC-6 Operator Maintenance - P)
026	end of Phase III Comprehensive test (Phase III Comprehensive)

[a]Type of Test: K - Knowledge, P - Performance

qualification changed from 900 points to 800. The school deleted Module #440. (It consisted of 28 elements of basic format messages testing memorization.)

In Phase II, the school shortened Module #550 by deleting most of the modes of operation and moving a portion of it to module #510. The school also shortened the radio wave propagation and deleted equipment nomenclature. The school currently includes instruction on an additional piece of equipment in Module #510. In Phase III, the school deleted module #132 (a performance test of broadcast operations).

In both old and new curricula, the school computes Final School Grade (FSG) as the average of all knowledge, performance, and comprehensive tests.

Sample. Our sample included only 6 students who completed the former curriculum. Thus, we did not conduct any analyses on the former curriculum. The remaining 293 students in our sample completed the current curriculum.

Results and Discussion. For the current curriculum, the retest variables showed very low variability, with between 0 and 73 retests (median 3.5) out of 291 cases; thus, we did not analyze any retest variables. Tests 511, 464, and 470 had standard deviations of zero, and Test 002 had a standard deviation of only .604, so we dropped these 4 variables from the analysis. Table 88 presents descriptive statistics on the variables which remained for the factor analysis.

The factor analysis indicated two factors. Table 89 shows the communalities, factor loadings, and factor score coefficients. The tests from Phase I and Phase II tend to load highest on Factor1, while tests from Phase III load higher on Factor2. To see how well simple composites could represent these factors, we created several composites, including Phase1 (the average of all tests in Phase I), Phase2 (the average of all tests in Phase II), and Phase3 (the average of all tests in Phase III). We computed Phase12 as the average of Phase1 and Phase2 to represent Factor1, while Phase3 represented Factor2. We also

Table 88
Descriptive Statistics for RM Variables

Variable	n	Mean	Std Dev	Skew	Kurtosis	Minimum	Maximum
Communication Organization - K	292	86.041	11.267	-1.042	1.223	44.000	100.000
Security - K	291	93.436	6.117	-1.089	1.515	65.000	100.000
Basic Message Format - K	291	88.804	9.405	-1.126	1.915	44.000	100.000
Phase I Comprehensive	291	92.357	6.642	-.643	-.315	68.000	100.000
Radiowave Propagation - K	291	90.955	9.278	-1.351	2.140	52.000	100.000
Safety - K	291	99.541	2.305	-6.110	41.978	80.000	100.000
Basic Communications Equipment - K	291	87.835	9.335	-.919	1.242	52.000	100.000
Communication System Construction - P	291	99.705	2.185	-9.761	109.436	71.400	100.000
Theater Nuclear Warfare - K	291	95.538	6.044	-1.533	2.470	66.700	100.000
Phase II Comprehensive	291	88.720	6.986	-.179	-.749	65.000	100.000
Message Processing Inrouter - P	291	98.287	4.317	-5.910	47.898	58.800	100.000
NAVMACS Initialization - K	291	90.892	7.290	-1.101	1.839	55.400	100.000
Message Processing Outrouter - K	291	91.942	7.769	-2.193	10.038	35.000	100.000
RTTY Circuit Operations - K	291	99.189	1.670	-2.486	6.813	90.000	100.000
Circuit Operations - K	291	93.634	6.396	-2.378	10.724	51.600	100.000
Phase III Comprehensive	291	91.005	7.300	-.795	.103	65.600	100.000

Table 89
Communalities, Factor Loadings, and Factor Score Coefficients for RM Variables

		Factor Loadings		Factor Score Coefficients	
Variable	Communality	Factor 1: Phase I & II	Factor 2: Phase III	Factor 1: Phase I & II	Factor 2: Phase III
Communication Organization - K	.350	.470	.359	.120	.085
Security - K	.343	.524	.263	.164	.021
Basic Message Format - K	.387	.600	.166	.259	-.085
Phase I Comprehensive	.273	.431	.296	.102	.051
Radiowave Propagation - K	.266	.459	.234	.126	.017
Safety - K	.015	-.009	.120	-.024	.054
Basic Communications Equipment - K	.340	.527	.249	.181	-.008
Communication System Construct. - P	.143	.327	-.190	.161	-.157
Theater Nuclear Warfare - K	.062	.202	.147	.039	.017
Phase II Comprehensive	.388	.483	.394	.122	.114
Message Processing Inrouter - P	.048	.042	.215	-.027	.081
NAVMACS Initialization - K	.402	.171	.610	-.017	.358
Message Processing Outrouter - K	.255	.348	.367	.058	.109
RTTY Circuit Operations - K	.149	.378	-.074	.163	-.123
Circuit Operations - K	.326	.204	.533	-.054	.257
Phase III Comprehensive	.326	.370	.435	.059	.132

Note. n = 290.

computed FSG2 (the simple average of all test scores), Know (the simple average of all knowledge tests), and Perf (the simple average of all Performance tests).

Table 90 displays descriptive statistics for these composite variables. Next, we computed Pearson correlation coefficients for the composite variables. Table 91 presents the composite variable intercorrelations. Since FSG and FSG2 correlate .99, this offers no support for using initial test scores to compute FSG.

Phase12 correlates highest (.92) with Factor1, followed closely by Know (.86), Phase1 (.85), and FSG (.84). Similarly, Phase3 correlates highest (.87) with Factor2, followed by FSG and Know (each .73). FSG correlates .93 with Phase12 and .80 with Phase3. These findings support using FSG as an indicator of performance on Phases 1 and 2 but suggest using a separate indicator for performance on Phase 3.

Table 90
Descriptive Statistics for RM Composite Variables

Composite	Rel[a]	Mean	Std Dev	Skew	Kurtosis	Minimum	Maximum
FSG	N/A	94.628	2.586	-.074	-.682	87.300	99.600
FSG2[b]	.80	93.005	3.511	-.213	-.540	83.240	99.530
Know[c]	.81	92.148	3.930	-.185	-.610	82.030	99.640
Perf[d]	.08	99.008	2.398	-5.046	33.826	79.400	100.000
Phase1[e]	.68	90.187	6.034	-.425	-.337	70.880	100.000
Phase2[f]	.52	93.707	3.654	-.394	-.363	82.900	100.000
Phase12[g]	.75	91.947	4.348	-.264	-.516	79.140	99.790
Phase3[h]	.60	94.182	3.547	-.576	-.303	83.920	100.000

Note. n = 290.
[a]These are composites based on communality estimates and the procedures described in the text.
[b]FSG2: FSG computed using initial test scores.
[c]Know: Average of all knowledge tests.
[d]Perf: Average of the 2 performance tests.
[e]Phase1: Average of the 4 Phase 1 tests.
[f]Phase2: Average of the 6 Phase 2 tests.
[g]Phase12: (Phase1 + Phase2)/2
[h]Phase3: Average of the 6 Phase 3 tests.

Table 91
Correlations Among RM Composites and Factors

Comp[a]	Fac1	Fac2	FSG	FSG2	Know	Perf	Phase1	Phase2	Phase12
Fac2	.29								
FSG	.84	.73							
FSG2[b]	.86	.73	.99						
Know[c]	.86	.73	.98	1.00					
Perf[d]	.23	.14	.29	.28	.20				
Phase1[e]	.85	.49	.84	.86	.86	.16			
Phase2[f]	.80	.47	.82	.84	.83	.24	.59		
Phase12[g]	.92	.54	.93	.95	.95	.21	.94	.83	
Phase3[h]	.49	.87	.80	.80	.79	.31	.53	.51	.58

Note. n = 290.
[a]These are composites based on communality estimates and the procedures described in the text.
[b]FSG2: FSG computed using initial test scores.
[c]Know: Average of all knowledge tests.
[d]Perf: Average of the 2 performance tests.
[e]Phase1: Average of the 4 Phase 1 tests.
[f]Phase2: Average of the 6 Phase 2 tests.
[g]Phase12: (Phase1 + Phase2)/2
[h]Phase3: Average of the 6 Phase 3 tests.

Recommendations. In addition to FSG, use Phase3 (an average of the tests in Phase 3).

Army Schools

Field Artillery Fire Support Specialist (13F)

Description of Variables. The 13F school has three areas of training: communications, map reading/land navigation, and fire support. The school generates composite scores for the instructional departments of Communications and Electronics (Test 1), Target Acquisition (Tests 2-4), and Fire Support and Combined Arms Operations (Tests 5-13). In addition, the school generates composite scores for branches within each department. The composite scores for the Communications and Electronics and Target Acquisition Departments equal their respective branch scores since each department has only one branch. The Fire Support and Combined Arms Operations Department branch composites consist of 13F duties and knowledge of the Fire Support Vehicle (FSV) (Tests 5 and 6), advanced 13F duties (Tests 7 and 8), and Target Shoots (9-11).

The school calculates composite scores by dividing the number of points achieved by the number of points possible. Since researchers can generate the composite scores from the test scores, we did not enter the composite scores in the database. The school calculates the Final School Grade (FSG) by taking the sum of all performance and written test scores and dividing by the number of points possible (1,000).

The school assigns a score equal to 70% of the test maximum to all retests. For each of Tests 1-13, the number of tries variables indicate the number of trials needed by the student to pass each test. A 0 equals test not administered, a 1 equals passed on first attempt, and a 2 equals passed on second attempt. The researchers recoded scores of 0 as missing. Each time the number of tries equals 2, the score will have a value equal to 70% of the maximum because the school assigns the minimum passing score to all those passing a retest.

Students receive an action code (see Appendix B) only if dropped from the class. The school provided information on each student's rank and the number of students in the class, each of which could range from 1 to 40. The researchers computed a measure of class standing using student rank (r) and class size (n): (class size - rank)/class size = (n-r)/n. The class standing variable puts students on a metric of 0 to approaching 1, so that the higher the standing, the better the student did relative to the other members of the class. Further, this measure takes into account class size. For example, a person who ranked first out of a class of 40 would have a standing of .975, while a person who ranked first out of a class of 5 would have a standing of .80.

The first 3 digits of the class number indicate the number of the class, the last 2 digits indicate the year of the class (90 or 91). Sometimes instructors divide classes into sections of approximately 10 students, indicated by the section number variable.

Approximately 26% of the trainees took part in a fast track training program. The fast track students had higher GT scores and higher initial entry scores than did the regular track students. The fast track soldiers received faster training which covered the same areas as that of the regular track, but also included additional training, some of which included skill level 2. The school gave tests 8 and 13 to fast track students only. Fast track students did not receive tests 7 and 12. Both tests 8 and 13 contained items covering the same content as tests 7 and 12, respectively, but also contained items covering the additional training the fast track students had received. Other than tests 7 and 8 and 12 and 13, both tracks received identical tests. The school scores tests 12 and 13 as pass/fail and does not include them in composite scores. The variables used for tests 12 and 13 indicate the number of trials needed to pass

each test. The school dropped the fast track program in October 1991.

Table 92 gives the specific test descriptions, where W refers to a written test and P refers to a performance test, and the numbers in parentheses give the valid ranges (from passing at the 70% level to the maximum possible). For each of Tests 1 through 13, we also recorded number of tries as a digit: 0 (recoded as missing), 1, or 2.

The school uses the sum of two map reading/land navigation performance tests (Tests 3 and 4) twice: once as the score for Test 3 and again as the score for Test 4. We excluded Test 4 and Trials 4 from the factor analysis. "All of the variables before the Final Test are commensurate (i.e., the same exercises scored the same) across tracks" (C. B. Walker, personal communication, January 23, 1992). For this reason, we combined Tests 7 and 8 into a single variable. All fast track students passed Test 13 (the final written test) on the first try. For this reason, the researchers combined Tests 12 and 13 into a single variable.

Table 92
Descriptions of 13F Variables

Test	Description	Type[a]	Passing Range
1	Radio and Communication	W	143.50-205.00
2	Map Symbols and Features	W	66.50- 95.00
3	Day Land Navigation by Terrain Association	P	28.00- 40.00
4	Map and Terrain Association Field Exercise	P	28.00- 40.00
5	Duties of the Fire Support Specialist	W	52.50- 75.00
6	Fire Support Vehicle (FSV)	P	94.50-135.00
7	Digital Message Device (DMD) & Firing Test for Regular Track Soldiers	W	77.00-110.00
8	Digital Message Device (DMD) & Firing Test for Fast Track Soldiers	W	77.00-110.00
9	Practice Shoot #1	P	70.00-100.00
10	Practice Shoot #2	P	70.00-100.00
11	Practice Shoot #3	P	70.00-100.00
12	Final Test, Regular Track (Pass/Fail), number of tries	W	digits 0, 1, or 2
13	Final Test, Fast Track (Pass/Fail), number of tries	W	digits 0, 1, or 2

Note. Each of Tests 1 through 11 also had a variable denoting the number of trials to pass the test, where 0 indicated test not administered, 1 indicated passed on first attempt, and 2 meant passed on second attempt.
[a]W = Written, P = Performance

Sample. The sample consisted of 755 regular track and 260 fast track soldiers (four cases had unspecified status). The researchers categorized soldiers into track status on the basis of Tests 7 and 8, since the data did not contain an explicit track indicator variable. Seventeen trainees who had scores on (the fast track) Test 8 also had scores on (the regular track) Final Exam Test 12 rather than (the fast track) Test 13.

The test forms contained three cases with values below the passing level, one each on Test 2, Test 5, and Test 7. Two of these cases had missing test data, and the researchers excluded them from factor analysis; the researchers retained the third case. The researchers excluded from analysis two cases which had entries for both Test 7 and Test 8. We excluded from further analysis the number of trials for Test 6 due to lack of variability. The final sample consisted of 1,006 cases: 750 regular track soldiers and 256 fast track soldiers.

Results and Discussion. We combined the two tracks for the analysis, since the sample consisted of only 26% fast track soldiers and the school dropped the fast track program in October 1991. Table 93 displays descriptive statistics for the variables. Because Tests 7 and 8 had the same timing and because the observed mean scores represent a conservative estimate of the difference between the regular and the fast track students, we considered it appropriate to treat Tests 7 and 8 as one variable.

Table 93
Descriptive Statistics for 13F Variables

Variable	Mean	Std Dev	Skew	Kurtosis	Minimum	Maximum
1 (Radio and Communication)	194.604	12.033	-1.622	2.702	143.500	205.000
2 (Map Symbols and Features)	81.808	8.681	-.316	-.872	66.500	95.000
3 (Day Land Navigation by Terrain Association)	33.153	4.427	.240	-1.297	28.000	40.000
4 (Map and Terrain Association Field Exercise)	33.153	4.427	.240	-1.297	28.000	40.000
5 (Duties of the Fire Support Specialist)	69.463	5.492	-2.600	20.948	3.000	75.000
6 (Fire Support Vehicle)	130.727	6.906	-2.077	5.026	94.500	135.000
7 (Digital Message Device & Firing Test, Regular) (n = 750)	93.058	9.431	-.121	-1.033	77.000	110.000
8 (Digital Message Device & Firing Test, Fast) (n = 256)	95.335	8.531	-.401	-.762	77.000	110.000
7 & 8 Combined (n = 1,006)	93.638	9.259	-.199	-.989	77.000	110.000
9 (Practice Shoot #1)	88.341	8.838	-.583	-.574	70.000	100.000
10 (Practice Shoot #2)	88.013	8.806	-.544	-.644	70.000	100.000
11 (Practice Shoot #3)	89.888	8.667	-.774	-.225	70.000	100.000
12 (Final Test, Regular) (n = 766)	1.085	.279	2.985	6.930	1.000	2.000
13 (Final Test, Fast) (n = 240)	1.000	.000	–	–	1.000	1.000
12 & 13 Combined (n = 1,006)	1.065	.246	3.547	10.605	1.000	2.000
Class Standing	.476	.285	.005	-1.193	.000	.974

Note. Total n = 1,006. 16 students who had taken Test 8 (Fast Track) took Test 12 (Regular Track) instead of Test 13.

The researchers first conducted factor analysis on the set of all test and trials variables (except Test 4, trials for Test 4, and trials for Test 6). The test variables correlated in the low range with one another (.048 to .338), indicating that the tests measure relatively independent aspects of the Fire Support Specialist duties. The scree test indicated two factors. However, the trials variables and the final exam displayed very low communalities (.037 to .220) and loadings (.013 to .457 in absolute value). We ran the factor analysis again without the trials variables and without the final exam, and we found the same two factors. Thus, we present these results based on analyzing just the tests.

Table 94 shows the communalities, factor loadings, and factor score coefficients. The primary factor consists of the sum of Tests 1, 2, 3, and 5. This factor resembles a "Map and Radio" factor due to the tests which load on it. The second factor contains Tests 7 & 8, 9, 10, and 11, which we labeled the "Firing" factor.

Table 94
Communalities, Factor Loadings, and Factor Score Coefficients for 13F Variables

Test	Communality	Factor Loadings		Factor Score Coefficients	
		Factor 1: Map & Radio	Factor 2: Firing	Factor 1: Map & Radio	Factor 2: Firing
1 (Radio & Communication)	.310	.515	.213	.274	.017
2 (Map Symbols & Features)	.396	.598	.197	.382	-.019
3 (Day Land Navigation)	.143	.368	.085	.168	-.028
5 (Duties of the FSS)	.265	.482	.180	.247	.003
6 Fire Support Vehicle)	.066	.108	.232	.009	.099
7&8 (Digital Message Dev.)	.292	.298	.451	.073	.231
9 (Practice Shoot #1)	.254	.140	.484	-.032	.277
10 (Practice Shoot #2)	.256	.149	.483	-.027	.276
11 (Practice Shoot #3)	.233	.102	.472	-.048	.272

Note. n = 1,006.

We sought to develop composite variables which would capture essential elements of the criterion variance and also represent meaningful content dimensions useful to the 13F school. Correlations with the empirical factors would illustrate the degree to which the simpler unit-weighted composites could represent the empirically defined factor. Accordingly, we developed the Map and Radio composite (the sum of Tests 1, 2, 3, and 5, divided by 415) to represent Factor 1, and the Firing composite (the sum of Tests 7 & 8, 9, 10, and 11, divided by 410) to represent Factor 2. The school uses FSG, so the researchers computed FSG2 (using initial test scores) to examine the pattern of intercorrelations with FSG. In order to examine whether a written test versus performance test distinction could explain aspects of school performance, we calculated the sum of the written tests (1, 2, 5, and 7 & 8) divided by 485 and the sum of the performance tests (3, 4, 6, 9, 10, and 11) divided by 515. We examined the sum of the final three tests (Tests 9, 10, and 11, the artillery shoots), because earlier research (Kieckhaefer & Brantner, 1990) had indicated their possible role in describing important aspects of 13F duties. Further the

school uses Communications and Electronics (Test 1), Target Acquisition (the sum of Tests 2, 3, and 4), and Fire Support and Combined Arms Operations (the sum of Tests 5 through 11) as composite scores. We placed all the composite variables (except class standing and the trials variable) on a 0-100 scale in order to compare them more readily.

Table 95 lists descriptive statistics on various composite variables, while Table 96 lists their intercorrelations and their correlations with the factors. Since FSG2 correlated nearly perfectly with FSG, this offers no support for computing FSG using initial test scores.

As indicated in Table 96, the Map and Radio composite correlated the highest (.98) with Factor 1, and the Firing composite correlated highest (.99) with Factor 2. These strong correlations and the relatively low intercorrelation between them (r = .38) make the Map & Radio and the Firing composites comprehensive and useful summary measures which at the same time measure different aspects of the Fire Support Specialist school performance.

FSG correlates less strongly with Factor 1 and Factor 2 (.79 and .82, respectively) and with Map and Radio and Firing (.81 and .82). This suggests FSG assesses both these areas.

Recommendations. In addition to FSG, use the Map & Radio and Firing composite scores.

Table 95
Descriptive Statistics for 13F Composite Variables

Composite	Rel[a]	Mean	Std Dev	Skew	Kurtosis	Min	Max
Map & Radio[b]	.60	91.308	3.346	-.829	.583	72.347	100.000
Firing[c]	.58	87.767	3.677	-.403	-.339	70.376	100.000
FSG	N/A	90.269	4.113	-.507	.006	75.700	99.300
FSG2[d]	.72	90.261	4.130	-.512	-.004	75.710	99.300
Writ[e]	.63	90.598	3.542	-.727	.339	72.907	100.000
Perf[f]	.58	89.945	3.323	-.428	-.262	75.825	100.000
Shoot[g]	.50	88.742	3.389	-.549	-.216	70.000	100.000
CE[h]	.31	94.902	2.678	-1.630	2.742	70.000	100.000
Target[i]	.62	84.622	3.369	-.047	-.891	70.000	100.000
Supp[j]	.60	90.319	3.527	-.516	-.142	76.913	99.495
Stand[k]	N/A	.476	.285	.005	-1.193	0.000	0.970
Trials[l]	N/A	1.048	.083	1.820	3.122	1.000	1.550

Note. n = 1,006.
[a]These are composites based on communality estimates and the procedures described in the text.
[b]Map & Radio: 100(Sum of Tests 1, 2, 3, 5)/415
[c]Firing: 100(Sum of Tests 7&8, 9, 10, 11)/410
[d]FSG2: FSG based on initial test scores.
[e]Writ: 100(Sum of Written Tests)/485
[f]Perf: 100(Sum of Performance Tests)/515
[g]Shoot: 100(Sum of Artillery Shoots)/300
[h]CE: 100(Test 1)/205
[i]Target: 100(Sum of Tests 2-4)/175
[j]Supp: 100(Sum of Tests 5-11)/620
[k]Stand: Class Standing=(class size - rank)/class size
[l]Trials: Mean number of attempts on Tests 1-13

Table 96

Correlations Among 13F Composites and Factors

Comp[a]	Fac 1	Fac 2	M & R	Firing	FSG	FSG2	Writ	Perf	Shoot	CE	Target	Supp	Stand
Fac 2	.33												
M & R[b]	.98	.36											
Firing[c]	.35	.99	.38										
FSG	.79	.82	.81	.82									
FSG2[d]	.79	.82	.81	.82	1.00								
Writ[e]	.92	.53	.92	.56	.85	.86							
Perf[f]	.42	.87	.46	.84	.84	.85	.45						
Shoot[g]	.25	.94	.31	.93	.74	.74	.38	.88					
CE[h]	.69	.30	.82	.28	.63	.63	.78	.28	.23				
Target[i]	.80	.24	.74	.29	.65	.65	.59	.51	.24	.32			
Supp[j]	.46	.97	.47	.95	.88	.88	.63	.87	.87	.33	.32		
Stand[k]	.75	.66	.76	.67	.87	.86	.78	.69	.59	.57	.63	.72	
Trials[l]	-.41	-.41	-.41	-.43	-.51	-.51	-.42	-.45	-.38	-.28	-.42	-.42	-.40

Note. n = 1,006.

[a]These are composites based on the procedures described in the text.

[b]Map & Radio: 100(Sum of Tests 1, 2, 3, 5)/415

[c]Firing: 100(Sum of Tests 7&8, 9, 10, 11)/410

[d]FSG2: FSG based on initial test scores.

[e]Writ: 100(Sum of Written Tests)/485

[f]Perf: 100(Sum of Performance Tests)/515

[g]Shoot: 100(Sum of Artillery Shoots)/300

[h]CE: 100(Test 1)/205

[i]Target: 100(Sum of Tests 2-4)/175

[j]Supp: 100(Sum of Tests 5-11)/620

[k]Stand: Class Standing=(class size - rank)/class size

[l]Trials: Mean number of attempts on Tests 1-13

Heavy Antiarmor Weapons Crewman (11H)

Descriptions of Variables. Students in the 11H school receive the same training and testing up until the point when they split up and attend either HMMWV or ITV training. First, the 11H school tests all students on 8 TOW Performance Training Objectives (TOs). Then the school tests all students in TOW Tracking Performance, consisting of up to 8 Events. After completing TOW 2 system training, students attend either HMMWV or ITV training school. Each ITV training objective consists of several performance measures, and most of the HMMWV TOs consist of several performance measures. The school then tests students on TOW simulator tracking measures for HMMWV and ITV schools. Students perform up to 3 Events for HMMWV and up to 5 Events for ITV.

We distinguished between students not tested on a performance measure and students with missing values on a performance measure. The numbers documented for each performance measure represent the number of NO GOs for that performance measure. For students who did not complete a task within the time allowed, the instructor documented subsequent performance measures with a NO GO.

The Student Action Code reflects why the 11H school dropped a student and has the following categories: 1=Medical Reasons, 2=Failed to Qualify, 3=Discharged, and 4=Unknown. The data contained no information on student action code.

TOW Performance TOs: The 8 TOW training objectives and performance measures consist of those shown in Table 97. The school instructors administered the several performance measures shown for each training objective as GO/NO GO performance tests.

Table 97
Performance Measures for 11H TOW Training Objectives

Training Objective	Performance Measures	
1: Assemble TOW Launcher	1. Place tripod legs in locked position 2. Level tripod 3. Carry traversing unit by control knobs 4. Lock groove coupling clamp 5. Carry daysight tracker 6. Lock daysight tracker 7. Secure launch tube 8. Handle nightsight properly	9. Check nightsight 10. Set nightsight FOV switch 11. Lock nightsight handle 12. Connect post amplifier cable 13. Connect battery 14. Install battery 15. Connect cell cord 16. Name each component.
2: Inspect TOW 2 Launcher and Missile	1. Conduct system check-out 2. Report malfunctions	3. Perform preoperational missile inspection.
3: Maintain TOW 2 Launcher	1. Conduct visual inspection 2. Describe correction of deficiencies 3. Name cleaning material 4. Report any deficiencies	5. Describe how to spot paint the launcher 6. Check desicant bags 7. Check humidity indicators.
4: Load Encased Missile	1. Lock down system 2. Raise bridge clamp and close trigger cover 3. Inspect missile 4. Remove electrical connector dust cover 5. Handle and load missile correctly 6. Use two hands to close and lock bridge clamp	7. Check backblast area 8. Raise arming lever 9. Lower arming lever 10. Unload missile correctly 11. Replace forward handling rings 12. Tag missile.
5: Action for TOW 2 Misfire	1. Check battery, coil cord connector & bridge clamp 2. Lower and raise arming lever	3. Perform correct actions after third misfire 4. Remain clear of front and rear of launcher.
6: Determine if Target is Engageable	1. Specify if target 1 is within range, engageable. or not engageable.	(Performance measures 2 through 5 follow similarly for targets 2 through 5.)
7: Prepare Antiarmor Range Card	1a. Correct weapon symbol 1b. Arrows drawn to weapons position 1c. Left and right limits 1d. All target engagement locations 1e. TRPs, to include the TRP number 1f. A maximum engagement line 1g. All prominent terrain features 1h. All dead space 1i. Unit, not to exceed company 1j. Magnetic north arrow 1k. Type of position	1l. Type of weapon 1m. Correct interval between circles 1n. Date 1o(1). Direction on target engagement locations 1o(2). Range on target engagement locations 1o(3). Description on target engagement locations 1o(4). TRP number for all TRPs on target engagement location 2. Ensure range card is readable 3. State two copies required.
8: Determine TOW Firing Limitations	1. Reduction of range over bodies of water 2. Fire from TOW carriers 3. Fire over electrical wires 4. Fire in windy conditions 5. Fire through smoke and area fires 6. Fire from bunkers and buildings	6a. Room size 6b. Ventilation 6c. Debris 6d. Noise 6e. Clearance requirements 6f. Muzzle clearance.

TOW Tracking Performance Events: The school uses a TOW Tracking Performance Scorecard to document students' TOW tracking scores. Students may perform in up to 8 Events. The school defines an Event as the sum of 10 shots. The score for each shot (0-100) reflects time on target from firing to hit/miss. We entered Event totals as they appeared on the scorecard. Researchers who calculate Event totals may find different Event totals than those reported by the school due to arithmetic errors by school instructors. The school defines the Qualification Score as the highest Event total. School instructors state that students frequently practiced more than what instructors documented on the scorecard. Each of Events 1 through 8 consist of 10 Event shots and a total score. The Qualification Score can range from 0-1000 and has the following categories: 0-549 Unqualified, 550-649 2ND Class, 650-749 1ST Class, and 750-1000 Expert. Thus, the school sets 550 as the minimum passing score for the TOW Tracking Performance.

The 11H school defines each shot as identical to the others, with the following exception. The school specifies that students wear protective masks for the last five shots in practice Event 2. We found that the instructor sometimes documents these scores elsewhere or does not document them at all.

HMMWV or ITV Training School: After completing TOW 2 system training, students attend either HMMWV or ITV training school. The training indication variable identifies which school the student attended. Most often, the qualification score for HMMWV or ITV training reflects the sum of ten shots on the student's final Event. However, we found cases where the qualification score does not reflect the student's final Event score or the highest score.

HMMWV TOs: The HMMWV TOs consist of the performance measures shown below:

1. Stow BII on HMMWV
2. Conduct PMCS on HMMWV

3. Install and Stow the M220A1
4. Destruction of the HMMWV
5. Prepare the M966: Squad Leader; Gunner; Loader/Driver
6. Load, Arm, Unload: Gunner; Loader/Driver
7. Reload: Gunner; Loader/Driver
8. Immediate Action: Squad Leader; Gunner; Loader; Driver
9. React to Fire Command: Squad Leader; Gunner; Loader/Driver
10. Dismount and Assemble the M220A2: Squad Leader; Gunner; Loader/Driver
11. Installing: Squad Leader; Gunner; Loader/Driver
12. Recognize Friendly and Threat Vehicles.

ITV TOs: The ITV TOs consist of the performance measures shown below:

1. M243 Smoke Grenade Launcher: Load; Arm; Fire; Unload
2. M60 Machine gun: Mount; Stow; Dismount
3. Crew Drill: Squad Leader; Gunner; Loader; Driver
4. Dismount and Assemble the M220A1: Squad Leader; Gunner; Loader; Driver
5. Intercom Equipment: Receive Message; Transmit Message
6. Turret Operation: Squad Leader; Gunner; Loader; Driver
7. Troubleshooting: Squad Leader; Gunner; Loader; Driver
8. Reload Dual Launcher: Gunner; Loader
9. Immediate Action: Squad Leader; Gunner; Loader; Driver
10. React to Fire Commands: Squad Leader; Gunner
11. Determine Target Engageability: Squad Leader; Gunner
12. Emergency Action Procedures: Squad Leader; Gunner; Loader
13. Manual Acquisition and Tracking: Squad Leader; Gunner; Loader
14. Engage Targets: Gunner

TOW Simulator Tracking Events: The final set of Event data represent TOW simulator tracking scores for HMMWV and ITV schools. Students perform up to 3 Events for HMMWV and up to 5 Events for ITV. (To determine whether these data represent HMMWV or ITV Events in the database, researchers should refer to the Training Indication Variable.) The HMMWV Events consist of M966 TOW Tracking Performance Events. The ITV Events consist of ITV Tracking Performance Events. We entered Event totals as they appeared on the scorecard. Again, researchers who calculate Event totals may find different Event totals than documented by the school due to instructors' errors. Finally, school instructors stated that students frequently practiced more than what instructors documented on the scorecard. Each of Events 1 through 5 consist of 10 identical Event shots (0-

100) and a total score (0-1000). The Qualification Score represents the highest event total, with the following classes: 0-599 Unqualified, 600-699 2ND Class, 700-799 1ST Class, and 800-1000 Expert. Thus, the school sets the minimum passing score for the HMMWV and ITV Simulator Tracking Performance Events as 600.

Sample. The ratio scale measures in the 11H school consist of the TOW Events, with shot scores that can range from 0 to 100, measuring time on target from firing to hit/miss. These occur after the 8 training objectives for all students and also at the end of training for ITV and HMMWV students separately. Since the two groups of students receive different training and different assessment after TOW 2 system training, it makes sense to analyze the two groups separately. The quantitative nature of the Event shot data make them amenable to factor analysis.

The ordinal data represent the number of NO GOs on each performance measure, the number of trials to pass the task. The Army requires that all trainees eventually pass, and empirically, almost all trainees pass on the first trial, resulting in little or no variability.

The researchers recoded the number of NO GOs so that higher scores represent better performance, i.e., 3 for passing on the initial trial (0 NO GOs); 2 for passing on the second trial (1 NO GO); and 1 for passing on the third trial (2 NO GOs). These item level data still resulted in limited variability.

The researchers then grouped item level data into meaningful content categories using the recoded number of NO GOs. We added scores within a TO to define a summary measure, which produced 8 TO measures for the first part of the testing. We used a similar approach for the separate ITV or HMMWV training. The ITV component contains 14 TOs, such as M243 Smoke Grenade Launcher, M60 Machine Gun, and others. Each TO has between 1 and 4 specific performance measures. The

HMMWV component contains 12 Training Objectives, such as Stow BII on the HMMWV, Conduct PMCS on a HMMWV, and others. Each has between 1 and 4 performance measures. These grouped scores for HMMWV and for ITV still exhibited extremely low variability, extreme negative skew, and large kurtosis.

We then made an effort to retain as many cases as possible when computing the TO and HMMWV and ITV summary measures by prorating. For example, for TO 1, which had 16 performance measures, we defined the TO 1 summary measure as the sum of the 16 scores divided by 16. If a case had scores on 15 of the 16 measures, we recoded the missing data value as 0, computed the sum, and divided by 15 (one less than the 16 measures, due to the missing score). The sample contained 714 HMMWV soldiers and 385 ITV soldiers.

Results and Discussion. We present results separately for HMMWV and for ITV students.

HMMWV: Table 98 presents descriptive statistics on the 11H variables for the HMMWV students.

We conducted factor analysis on TOs 1, 2, 4, 5, and 7; the HUMMWV sum; the 10 shots each for events 1-3; and the 10 shots for the TOW event 1. The correlation matrix of these variables had a determinant of zero, which may indicate collinearity among two or more variables. However, examination of the correlation matrix did not reveal any variables having linear combinations of other variables. TO 4 had a communality of .99, but if TO 4 were perfectly predictable from other variables, it would have a communality of exactly 1.00. Further, even with the TO variables and the HMMWV sum removed, the correlation matrix of the event shots still had a determinant of zero. None of these other communalities even approached 1.00. Thus, we present the following conclusions as tentative under the above proviso of the singular correlation matrix.

Table 9a

Descriptive Statistics for 11H HMMWV Variables

Variable	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
TO 1	2.979	.148	-11.370	140.740	1.000	3.000
TO 2	2.971	.143	-8.876	106.179	1.000	3.000
TO 4	2.974	.108	-10.374	123.676	1.533	3.000
TO 5	2.981	.151	-10.961	132.383	1.000	3.000
TO 7	2.958	.088	-6.124	58.905	2.000	3.000
Ev 1 Sh 1	47.216	20.780	-.392	-.210	.000	100.000
Ev 1 Sh 2	49.551	20.852	-.501	-.078	.000	100.000
Ev 1 Sh 3	50.097	21.268	-.618	-.119	.000	91.000
Ev 1 Sh 4	49.533	20.451	-.524	-.132	.000	100.000
Ev 1 Sh 5	49.733	20.638	-.561	-.011	.000	98.000
Ev 1 Sh 6	50.513	20.503	-.705	.203	.000	96.000
Ev 1 Sh 7	50.721	21.045	-.722	.063	.000	94.000
Ev 1 Sh 8	50.556	20.275	-.640	.070	.000	98.000
Ev 1 Sh 9	50.677	20.993	-.598	-.088	.000	100.000
Ev 1 Sh 10	50.141	21.476	-.620	-.177	.000	99.000
Ev 2 Sh 1	56.154	17.984	-.700	.635	.000	100.000
Ev 2 Sh 2	57.463	19.331	-.898	.948	.000	98.000
Ev 2 Sh 3	57.574	19.150	-.940	.851	.000	100.000
Ev 2 Sh 4	57.812	18.140	-.930	1.054	.000	95.000
Ev 2 Sh 5	58.062	17.988	-.937	1.072	.000	100.000
Ev 2 Sh 6	57.819	18.685	-.861	.984	.000	100.000
Ev 2 Sh 7	57.528	18.954	-1.021	1.180	.000	98.000
Ev 2 Sh 8	57.867	18.781	-1.078	1.470	.000	96.000
Ev 2 Sh 9	58.062	18.472	-.905	1.183	.000	100.000
Ev 2 Sh 10	55.751	19.500	-.904	.807	.000	97.000
Ev 3 Sh 1	64.569	13.305	-1.059	4.075	.000	100.000
Ev 3 Sh 2	65.509	12.396	-1.115	4.792	.000	96.000
Ev 3 Sh 3	65.860	12.636	-1.102	4.528	.000	100.000
Ev 3 Sh 4	66.034	12.659	-.979	3.920	.000	100.000
Ev 3 Sh 5	65.593	13.046	-1.247	4.939	.000	95.000
Ev 3 Sh 6	65.522	12.619	-.671	1.992	.000	99.000
Ev 3 Sh 7	65.619	12.393	-.523	1.218	10.000	98.000
Ev 3 Sh 8	65.692	13.504	-1.119	3.754	.000	98.000
Ev 3 Sh 9	66.198	12.427	-.550	1.608	4.000	98.000
Ev 3 Sh 10	65.835	13.155	-.910	3.318	.000	100.000
HMMWV Sum	2.997	.020	-6.782	47.380	2.833	3.000
TOW Ev 1 Sh 1	65.252	12.108	-1.148	3.644	.000	98.000
TOW Ev 1 Sh 2	65.549	12.345	-1.162	4.270	.000	95.000
TOW Ev 1 Sh 3	65.907	12.010	-1.301	4.892	.000	100.000
TOW Ev 1 Sh 4	66.750	12.707	-1.452	5.561	.000	98.000
TOW Ev 1 Sh 5	67.174	12.011	-1.239	3.977	.000	92.000
TOW Ev 1 Sh 6	66.501	12.211	-1.176	3.989	.000	98.000
TOW Ev 1 Sh 7	66.578	13.065	-1.560	5.266	.000	94.000
TOW Ev 1 Sh 8	66.914	12.712	-1.241	4.106	.000	97.000
TOW Ev 1 Sh 9	67.253	12.940	-1.217	4.013	.000	99.000
TOW Ev 1 Sh 10	67.342	12.521	-1.008	3.478	.000	100.000

Note. n = 714.

Factor analysis indicates five factors. Table 99 shows the communalities and factor loadings, while Table 100 shows the factor score coefficients. Factor 1 clearly consists of the 10 shots for Event 3. The 10 shots for Event 1 defined Factor 2, while the 10 shots for Event 2 defined Factor 3. Factor 4 consists of the 10 shots for the first TOW Event. Finally, the fifth factor consists of TO 1, TO 4, TO 5, and TO 7.

In order to represent important dimensions of the HMMWV student performance in the 11H school, the researchers developed composite variables based on the empirical factors which emerged from the factor analysis. Total score on the 10 shots in Event 3 constituted the most important dimension. This total score usually corresponds to the qualification score, because by then the students have practiced shooting enough that their scores have increased sufficiently. The shots for Events 1 and 2 and the TOW Event 1 loaded on Factors 2, 3, and 4, respectively. Finally, the measure of training objective performance consisted of the average (on a 0-3 scale) of the prorated training objective scores for which the soldiers exhibited variability (TOs 1, 2, 4, 5, and 7).

Table 99
Communalities and Factor Loadings for 11H HMMWV Variables

Variable	Communality	Factor Loadings 1	2	3	4	5
TO 1	.990	.032	.031	.019	-.003	.994
TO 2	.035	.095	-.013	.130	-.016	.091
TO 4	.989	.035	.038	.028	.001	.993
TO 5	.949	.019	.044	.046	-.005	.972
TO 7	.457	.069	.097	.039	-.021	.664
Ev 1 Sh 1	.363	.128	.567	.152	.037	.027
Ev 1 Sh 2	.429	.128	.613	.189	.035	.008
Ev 1 Sh 3	.497	.209	.626	.230	.075	.058
Ev 1 Sh 4	.546	.141	.679	.250	.040	.020
Ev 1 Sh 5	.552	.157	.700	.190	.033	-.006
Ev 1 Sh 6	.528	.083	.689	.208	.054	.025
Ev 1 Sh 7	.523	.126	.686	.184	.051	.016
Ev 1 Sh 8	.494	.177	.651	.194	.009	.040
Ev 1 Sh 9	.494	.238	.621	.209	.054	.068
Ev 1 Sh 10	.471	.225	.618	.194	-.002	.041
Ev 2 Sh 1	.419	.180	.326	.518	.063	.092
Ev 2 Sh 2	.484	.227	.308	.580	.019	.028
Ev 2 Sh 3	.503	.164	.294	.620	.034	.066
Ev 2 Sh 4	.545	.244	.295	.628	.063	.018
Ev 2 Sh 5	.550	.221	.338	.620	.032	.047
Ev 2 Sh 6	.575	.248	.262	.661	.077	-.047
Ev 2 Sh 7	.605	.235	.284	.685	.000	.012
Ev 2 Sh 8	.494	.309	.230	.588	.011	.010
Ev 2 Sh 9	.526	.308	.233	.612	.033	-.042
Ev 2 Sh 10	.516	.326	.274	.578	-.013	-.003
Ev 3 Sh 1	.475	.623	.168	.239	.037	-.007
Ev 3 Sh 2	.452	.619	.157	.207	.025	.019
Ev 3 Sh 3	.526	.670	.184	.204	-.032	-.008
Ev 3 Sh 4	.500	.658	.129	.209	.083	.013
Ev 3 Sh 5	.560	.694	.196	.193	.057	-.018
Ev 3 Sh 6	.445	.618	.183	.156	.031	.065
Ev 3 Sh 7	.527	.686	.148	.185	.027	.003
Ev 3 Sh 8	.523	.681	.126	.159	.109	.077
Ev 3 Sh 9	.530	.693	.145	.161	.021	.053
Ev 3 Sh 10	.501	.667	.149	.173	.026	.054
HMMWV Sum	.009	-.061	-.026	-.037	.058	-.007
TOW Ev1 Sh1	.281	.012	.086	.001	.523	-.004
TOW Ev1 Sh2	.372	.021	.047	.012	.606	-.037
TOW Ev1 Sh3	.462	.060	.003	.061	.674	.013
TOW Ev1 Sh4	.432	.045	.039	.049	.653	.003
TOW Ev1 Sh5	.539	-.019	.001	.040	.733	.020
TOW Ev1 Sh6	.427	-.027	.038	.019	.651	.032
TOW Ev1 Sh7	.476	.097	.003	.038	.682	.017
TOW Ev1 Sh8	.490	.049	.048	-.017	.693	-.065
TOW Ev1 Sh9	.436	.045	.032	.001	.658	.010
TOW Ev1 S10	.507	.004	.025	.025	.711	-.020

Table 100
Factor Score Coefficients for 11H HMMWV Variables

Variable	Factor Score Coefficients 1	2	3	4	5
TO 1	.024	-.016	-.113	-.037	.495
TO 2	.006	-.012	.013	-.002	.008
TO 4	.002	-.024	.047	.053	.402
TO 5	-.054	-.003	.069	-.006	.112
TO 7	.006	.014	-.005	-.007	-.005
Ev 1 Sh 1	-.012	.105	-.038	-.001	.016
Ev 1 Sh 2	-.022	.130	-.038	.001	-.006
Ev 1 Sh 3	-.005	.135	-.039	.006	-.003
Ev 1 Sh 4	-.036	.167	-.037	-.003	-.004
Ev 1 Sh 5	-.020	.183	-.067	-.008	-.001
Ev 1 Sh 6	-.042	.166	-.043	-.002	-.003
Ev 1 Sh 7	-.031	.172	-.057	.001	-.010
Ev 1 Sh 8	-.010	.151	-.054	-.010	-.025
Ev 1 Sh 9	.004	.130	-.049	.005	-.005
Ev 1 Sh 10	.000	.132	-.049	-.014	.009
Ev 2 Sh 1	-.030	.007	.097	.002	-.005
Ev 2 Sh 2	-.026	-.017	.136	-.007	.027
Ev 2 Sh 3	-.052	-.020	.168	-.004	-.001
Ev 2 Sh 4	-.032	-.032	.174	.004	-.014
Ev 2 Sh 5	-.038	-.011	.158	-.004	-.009
Ev 2 Sh 6	-.033	-.052	.198	.013	-.007
Ev 2 Sh 7	-.048	-.041	.219	-.011	-.001
Ev 2 Sh 8	-.003	-.039	.130	-.007	-.000
Ev 2 Sh 9	-.009	-.047	.163	-.000	-.008
Ev 2 Sh 10	.000	-.029	.132	-.017	-.004
Ev 3 Sh 1	.123	-.021	-.017	-.005	-.012
Ev 3 Sh 2	.116	-.017	-.022	-.004	.009
Ev 3 Sh 3	.149	-.015	-.036	-.022	-.004
Ev 3 Sh 4	.136	-.032	-.025	.011	-.006
Ev 3 Sh 5	.168	-.012	-.053	.002	.001
Ev 3 Sh 6	.116	-.006	-.039	-.003	.004
Ev 3 Sh 7	.159	-.027	-.042	-.005	.003
Ev 3 Sh 8	.154	-.025	-.042	.013	-.020
Ev 3 Sh 9	.165	-.020	-.053	-.008	.005
Ev 3 Sh 10	.141	-.018	-.041	-.007	-.006
HMMWV Sum	-.005	-.002	.001	.006	-.011
TOW Ev1 Sh1	-.005	.014	-.017	.080	-.012
TOW E 1 Sh2	-.004	.002	-.005	.111	.002
TOW Ev1 Sh3	.002	-.016	.005	.134	-.011
TOW Ev1 Sh4	-.006	-.007	.004	.126	.010
TOW Ev1 Sh5	-.021	-.020	.019	.178	.018
TOW Ev1 Sh6	-.015	.003	-.002	.122	.015
TOW Ev1 Sh7	.009	-.018	.001	.139	-.014
TOW Ev1 Sh8	.003	.007	-.024	.150	.003
TOW Ev1 Sh9	.005	-.002	-.015	.122	.002
TOW Ev1 S10	-.013	-.008	.004	.161	-.004

Table 101 provides descriptive statistics on these composites, and Table 102 displays their correlations with the factors and among the composites. Table 101 presents composite reliabilities calculated by two distinct methods. The first column presents reliabilities calculated using communality estimates from factor analysis. The second method presents reliabilities for the Events under the assumption that each shot within an Event constitutes an independent replication. The researchers computed the mean of the inter-shot (interitem) correlations within each Event. The reliabilities computed from the communality estimates (.83 to .92) exceeded the average inter-shot correlations (.43 to .51).

In Table 102. the strong correlation (from .90 to 1.00) between each factor and its corresponding composite supports use of the composite variables. Further, the relatively strong correlations between the totals for Events 1 to 3 (.63, .46, .58) indicate that the three Events measure some common higher-order factor. We factor analyzed the correlation matrix of the three Event totals and found one strong factor. Event 1, 2, and 3 totals had the following factor properties: communalities: .501, .791, and .424; factor loadings: .708, .889, and .651; and factor score coefficients: .217, .652, and .173.

Table 101
Descriptive Statistics for 11H HMMWV Composite Variables

Composite	Rel[a]	Rel[b]	Mean	SD	Skew	Kurtosis	Minimum	Maximum
TO[c]	.90	N/A	2.974	.108	-10.374	123.676	1.533	3.000
Ev 1 Total	.90	.48	498.844	152.727	-.496	.109	0.000	844.000
Ev 2 Total	.92	.51	574.098	140.664	-.718	.756	25.000	910.000
Ev 3 Total	.91	.50	656.432	95.332	-.986	4.511	70.000	923.000
TOW Ev 1 Total	.89	.43	665.557	89.536	-1.500	5.883	62.000	874.000

[a]These are composites based on communality estimates and the procedures described in the text.
[b]Mean inter-shot correlation within each Event.
[c]TO: (TO 1 + TO 2 + TO 4 + TO 5 + TO 7)/5

Table 102
Correlations Among 11H HMMWV Composites and Factors

Composite	Fac 1	Fac 2	Fac 3	Fac 4	Fac 5	TO	Ev 1	Ev 2	Ev 3
Factor 2	.03								
Factor 3	.07	.09							
Factor 4	.01	.01	.00						
Factor 5	.00	.00	-.00	-.00					
TO[a]	.06	.05	.07	-.01	.95				
Ev 1 Total	.24	.95	.30	.06	.04	.11			
Ev 2 Total	.35	.41	.90	.04	.02	.11	.63		
Ev 3 Total	.96	.23	.28	.06	.03	.11	.46	.58	
TOW Ev 1 Total	.04	.05	.04	1.00	-.00	-.01	.10	.10	.10

[a]TO: (TO 1 + TO 2 + TO 4 + TO 5 + TO 7)/5

ITV: Table 103 shows the descriptive statistics on the ITV variables included in the factor analysis. The researchers eliminated the measure for TO 6 due to lack of variability. As with the HMMWV variables, all the ITV variables demonstrated negative skew, indicating a ceiling effect.

Factor analysis indicates 7 factors, with the communalities and loadings shown in Table 104 and the factor score coefficients in Table 105. As with the HMMWV data, the ITV correlation matrix had a determinant of zero. This singular correlation matrix tempers the conclusions derived from this analysis. The shots for Event 1 defined the primary factor, while the shots for Event 3 defined the second factor. The shots for the first ITV Event defined the third factor, while the shots for Event 2 defined the fourth factor. Factor 5 consisted of the training objectives, while factors 6 and 7 consisted of the shots for ITV Events 3 and 2, respectively.

Table 103
Descriptive Statistics for 11H ITV Variables

Variable	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
TO 1	2.996	.024	-8.494	85.695	2.688	3.000
TO 2	2.984	.096	-7.391	63.227	2.000	3.000
TO 3	2.996	.028	-7.607	62.887	2.714	3.000
TO 4	2.997	.021	-7.540	66.022	2.750	3.000
TO 5	2.994	.042	-7.914	69.458	2.500	3.000
TO 7	2.971	.057	-2.455	7.309	2.600	3.000
Ev 1 Sh 1	46.070	21.695	-.453	-.444	.000	100.000
Ev 1 Sh 2	48.419	21.438	-.538	-.303	.000	100.000
Ev 1 Sh 3	48.901	21.821	-.566	-.328	.000	90.000
Ev 1 Sh 4	49.580	21.784	-.594	-.120	.000	100.000
Ev 1 Sh 5	51.115	19.576	-.671	.089	.000	95.000
Ev 1 Sh 6	50.627	20.475	-.637	.103	.000	100.000
Ev 1 Sh 7	49.817	21.545	-.467	-.368	.000	100.000
Ev 1 Sh 8	49.368	21.138	-.591	-.161	.000	94.000
Ev 1 Sh 9	49.632	21.109	-.562	-.296	.000	92.000
Ev 1 Sh 10	49.890	21.202	-.735	-.047	.000	100.000
Ev 2 Sh 1	55.676	19.167	-.983	.929	.000	92.000
Ev 2 Sh 2	56.308	18.388	-.987	1.001	.000	95.000
Ev 2 Sh 3	59.640	17.802	-.937	1.118	.000	98.000
Ev 2 Sh 4	57.862	17.733	-.916	1.119	.000	91.000
Ev 2 Sh 5	58.728	17.825	-.978	1.325	.000	95.000
Ev 2 Sh 6	58.065	18.145	-.837	.722	.000	95.000
Ev 2 Sh 7	58.063	18.277	-.895	1.193	.000	97.000
Ev 2 Sh 8	57.783	18.882	-.961	1.046	.000	99.000
Ev 2 Sh 9	58.325	18.604	-.919	1.044	.000	99.000
Ev 2 Sh 10	57.157	19.487	-.815	.724	.000	97.000
Ev 3 Sh 1	65.806	13.538	-.957	2.691	.000	100.000
Ev 3 Sh 2	66.228	13.158	-.657	1.797	.000	98.000
Ev 3 Sh 3	65.961	13.112	-.880	2.589	.000	96.000
Ev 3 Sh 4	65.364	13.211	-.952	2.803	.000	95.000
Ev 3 Sh 5	65.678	13.125	-.867	3.078	.000	93.000
Ev 3 Sh 6	67.197	12.961	-.704	2.022	5.000	96.000
Ev 3 Sh 7	65.824	13.522	-.734	1.793	8.000	99.000
Ev 3 Sh 8	67.060	14.052	-1.223	3.862	.000	95.000
Ev 3 Sh 9	66.433	12.820	-1.281	4.835	.000	97.000
Ev 3 Sh 10	67.016	14.012	-1.018	2.640	5.000	95.000
ITV Sum	2.999	.007	-6.331	44.685	2.929	3.000
ITV Ev 1 Sh 1	50.342	23.117	-.715	-.193	.000	98.000
ITV Ev 1 Sh 2	53.008	22.210	-.588	-.044	.000	98.000
ITV Ev 1 Sh 3	53.070	22.590	-.717	.079	.000	96.000
ITV Ev 1 Sh 4	52.854	23.031	-.635	-.102	.000	100.000
ITV Ev 1 Sh 5	52.809	22.083	-.728	.155	.000	100.000
ITV Ev 1 Sh 6	54.655	22.028	-.709	.087	.000	99.000
ITV Ev 1 Sh 7	53.880	22.521	-.674	-.087	.000	100.000
ITV Ev 1 Sh 8	54.535	22.488	-.704	.116	.000	100.000
ITV Ev 1 Sh 9	53.256	21.957	-.736	.229	.000	100.000
ITV Ev 1 Sh 10	52.726	22.473	-.707	.051	.000	100.000

Table 103 (Continued)

Variable	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
ITV Ev 2 Sh 1	57.688	18.687	-.846	.697	.000	96.000
ITV Ev 2 Sh 2	58.122	20.120	-.867	.867	.000	100.000
ITV Ev 2 Sh 3	59.482	19.652	-1.007	.819	.000	92.000
ITV Ev 2 Sh 4	58.172	20.909	-1.044	.993	.000	96.000
ITV Ev 2 Sh 5	58.201	19.328	-.808	.639	.000	95.000
ITV Ev 2 Sh 6	58.547	20.447	-1.016	1.145	.000	99.000
ITV Ev 2 Sh 7	59.542	18.845	-.935	1.018	.000	95.000
ITV Ev 2 Sh 8	58.823	20.213	-.921	.754	.000	98.000
ITV Ev 2 Sh 9	58.089	20.554	-.887	.801	.000	96.000
ITV Ev 2 Sh 10	57.898	19.251	-.822	.882	.000	97.000
ITV Ev 3 Sh 1	68.219	12.213	-.521	2.169	.000	100.000
ITV Ev 3 Sh 2	69.204	12.780	-.931	3.118	.000	100.000
ITV Ev 3 Sh 3	68.339	12.276	-.997	4.489	.000	98.000
ITV Ev 3 Sh 4	68.232	13.302	-.697	2.779	.000	99.000
ITV Ev 3 Sh 5	68.862	12.262	-.253	-.003	26.000	95.000
ITV Ev 3 Sh 6	67.465	12.481	-.718	2.224	5.000	97.000
ITV Ev 3 Sh 7	68.269	12.833	-.572	2.446	.000	100.000
ITV Ev 3 Sh 8	68.256	12.832	-.668	1.962	.000	96.000
ITV Ev 3 Sh 9	69.407	12.998	-.472	.743	20.000	100.000
ITV Ev 3 Sh 10	67.911	13.599	-.962	2.903	.000	96.000

Note. n = 385.

Table 104
Communalities and Factor Loadings for 11H ITV Variables

Variable	Communality	Factor Loadings 1	2	3	4	5	6	7
TO 1	.792	.061	.056	.026	-.002	.886	.011	.017
TO 2	.050	-.075	-.019	-.055	.071	.181	.056	.003
TO 3	.936	.053	.065	.011	-.034	.963	.004	.015
TO 4	.951	.056	.024	.041	-.021	.971	.016	.032
TO 5	.776	.022	.094	-.004	-.063	.873	.004	.008
TO 7	.083	-.005	-.030	-.014	.047	.271	-.006	-.080
Ev 1 Sh 1	.516	.673	.159	-.030	.175	.069	.006	.039
Ev 1 Sh 2	.525	.705	.095	-.010	.102	.032	.079	.024
Ev 1 Sh 3	.619	.759	.137	.034	.129	.007	.082	.001
Ev 1 Sh 4	.565	.705	.121	.047	.196	.011	.074	.082
Ev 1 Sh 5	.491	.669	.068	.001	.167	-.093	.051	-.014
Ev 1 Sh 6	.570	.707	.093	.061	.237	.014	.019	-.024
Ev 1 Sh 7	.549	.693	.089	.120	.200	-.056	.040	.052
Ev 1 Sh 8	.583	.658	.124	.089	.334	-.008	.073	.098
Ev 1 Sh 9	.546	.685	.117	.041	.231	.069	.038	.046
Ev 1 Sh 10	.484	.647	.076	.034	.227	-.067	.007	.050

Table 104 (Continued)

Variable	Communality	Factor Loadings 1	2	3	4	5	6	7
Ev 2 Sh 1	.392	.425	.113	.012	.435	.089	.027	.027
Ev 2 Sh 2	.506	.426	.107	.040	.549	.061	.052	-.064
Ev 2 Sh 3	.536	.338	.130	.024	.633	.057	.020	.022
Ev 2 Sh 4	.550	.360	.202	.038	.609	-.035	.080	-.014
Ev 2 Sh 5	.561	.351	.157	.014	.626	.059	.120	.052
Ev 2 Sh 6	.503	.429	.209	.056	.515	.029	.082	.012
Ev 2 Sh 7	.602	.290	.231	.025	.677	.002	.064	.037
Ev 2 Sh 8	.612	.294	.290	-.014	.664	.016	.012	.001
Ev 2 Sh 9	.609	.344	.199	.029	.668	.001	.051	.035
Ev 2 Sh 10	.558	.319	.215	.101	.625	-.010	-.007	.091
Ev 3 Sh 1	.358	.287	.490	.024	.188	-.016	-.001	.012
Ev 3 Sh 2	.556	.225	.679	.136	.151	-.029	.048	.007
Ev 3 Sh 3	.555	.120	.712	.130	.109	-.025	-.017	-.059
Ev 3 Sh 4	.503	.144	.650	.176	.137	-.097	-.018	-.010
Ev 3 Sh 5	.504	.173	.664	.037	.158	.012	-.010	.080
Ev 3 Sh 6	.579	.049	.744	.041	.128	-.017	.048	.042
Ev 3 Sh 7	.575	.048	.742	-.011	.083	.081	.005	.094
Ev 3 Sh 8	.591	.116	.746	.034	.106	.071	.052	.037
Ev 3 Sh 9	.472	.074	.658	.035	.113	.065	.086	.088
Ev 3 Sh 10	.502	.087	.681	-.003	.135	.022	.039	.100
ITV Sum	.017	.040	-.074	.022	.052	-.032	-.016	-.074
ITV Ev 1 Sh 1	.314	.055	.005	.512	.000	.037	.110	.188
ITV Ev 1 Sh 2	.319	-.039	.048	.518	-.007	-.054	.069	.197
ITV Ev 1 Sh 3	.373	.067	.068	.580	.018	-.022	.061	.149
ITV Ev 1 Sh 4	.430	.115	.081	.608	.081	-.073	.119	.119
ITV Ev 1 Sh 5	.425	.010	-.023	.607	.013	.032	.149	.182
ITV Ev 1 Sh 6	.445	-.011	.072	.598	.082	-.016	.098	.257
ITV Ev 1 Sh 7	.465	.049	.098	.661	.009	-.004	.102	.070
ITV Ev 1 Sh 8	.400	-.021	.027	.590	.028	.042	.142	.166
ITV Ev 1 Sh 9	.360	.084	.038	.540	.037	.054	.203	.120
ITV Ev 1 Sh 10	.331	-.004	.051	.516	-.039	-.066	.138	.194
ITV Ev 2 Sh 1	.315	.014	.018	.332	.025	.014	.095	.441
ITV Ev 2 Sh 2	.305	-.013	.031	.323	.007	-.052	.181	.406
ITV Ev 2 Sh 3	.401	.025	.037	.319	.056	-.088	.071	.530
ITV Ev 2 Sh 4	.392	.090	.029	.291	.052	-.038	.153	.521
ITV Ev 2 Sh 5	.363	.017	-.044	.201	-.011	-.036	.264	.500
ITV Ev 2 Sh 6	.451	.068	.083	.241	.053	.037	.195	.583
ITV Ev 2 Sh 7	.453	.065	.076	.253	-.050	.005	.172	.589
ITV Ev 2 Sh 8	.368	.137	.048	.314	.100	.050	.194	.445
ITV Ev 2 Sh 9	.487	.006	.085	.307	.029	-.038	.242	.570
ITV Ev 2 Sh 10	.350	.018	.102	.226	.015	-.043	.203	.495
ITV Ev 3 Sh 1	.391	-.001	.031	.141	.053	-.055	.574	.188
ITV Ev 3 Sh 2	.261	.053	.001	.123	.026	.029	.479	.112
ITV Ev 3 Sh 3	.355	.048	.129	.073	.026	-.003	.565	.101
ITV Ev 3 Sh 4	.361	.031	.005	.073	.085	.034	.586	.056
ITV Ev 3 Sh 5	.312	.050	.072	.104	-.025	.050	.501	.198
ITV Ev 3 Sh 6	.320	-.005	.034	.047	.116	.012	.546	.067
ITV Ev 3 Sh 7	.332	.077	-.077	.149	.011	-.004	.531	.125
ITV Ev 3 Sh 8	.390	.040	.025	.159	.017	.043	.595	.078
ITV Ev 3 Sh 9	.329	.049	.023	.169	-.026	-.021	.532	.119
ITV Ev 3 Sh 10	.343	.037	-.023	.080	-.012	.028	.571	.089

Table 105
Factor Score Coefficients for 11H ITV Variables

Variable	Factor Score Coefficients 1	2	3	4	5	6	7
TO 1	-.003	.042	-.012	-.003	-.192	.004	-.028
TO 2	-.010	.003	-.014	.008	-.003	.013	.004
TO 3	.070	.009	.033	-.082	.626	-.030	-.014
TO 4	-.019	-.091	.043	.038	.737	-.020	.060
TO 5	-.037	.040	-.034	.004	-.190	.016	.004
TO 7	-.006	-.003	.006	.011	-.008	.007	-.021
Ev 1 Sh 1	.123	-.000	-.030	-.055	.008	-.022	.028
Ev 1 Sh 2	.146	-.002	-.021	-.089	.004	.020	-.001
Ev 1 Sh 3	.214	.003	-.002	-.130	.002	.016	-.032
Ev 1 Sh 4	.144	-.014	-.016	-.062	-.012	.001	.026
Ev 1 Sh 5	.110	-.013	-.011	-.040	-.048	.007	-.016
Ev 1 Sh 6	.149	-.024	.025	-.048	.025	-.011	-.040
Ev 1 Sh 7	.146	-.017	.021	-.067	-.037	-.020	-.005
Ev 1 Sh 8	.116	-.015	-.002	-.008	-.029	-.004	.021
Ev 1 Sh 9	.123	-.009	-.010	-.036	-.017	-.006	.009
Ev 1 Sh 10	.103	-.022	.001	-.032	-.014	-.019	.012
Ev 2 Sh 1	.021	-.016	-.011	.064	.010	-.006	.010
Ev 2 Sh 2	.009	-.026	.020	.115	.020	.005	-.045
Ev 2 Sh 3	-.028	-.037	-.002	.169	.008	-.021	.009
Ev 2 Sh 4	-.019	-.009	.004	.145	-.021	.018	-.035
Ev 2 Sh 5	-.031	-.030	-.024	.169	.007	.029	.013
Ev 2 Sh 6	.016	-.008	.005	.079	.009	.011	-.016
Ev 2 Sh 7	-.069	-.009	-.010	.218	-.016	.002	.003
Ev 2 Sh 8	-.068	.005	-.019	.211	.037	-.008	-.006
Ev 2 Sh 9	-.040	-.021	-.014	.198	.024	-.003	.005
Ev 2 Sh 10	-.035	-.016	.018	.156	-.000	-.046	.035
Ev 3 Sh 1	.014	.050	-.009	-.006	.014	-.011	.002
Ev 3 Sh 2	.013	.141	.038	-.044	.011	.009	-.050
Ev 3 Sh 3	-.016	.153	.046	-.028	-.022	-.014	-.073
Ev 3 Sh 4	-.004	.124	.049	-.027	-.037	-.020	-.046
Ev 3 Sh 5	-.002	.115	-.017	-.020	.024	-.020	.028
Ev 3 Sh 6	-.027	.175	-.025	-.025	-.053	.015	-.003
Ev 3 Sh 7	-.024	.157	-.044	-.036	.012	-.013	.040
Ev 3 Sh 8	-.013	.186	-.012	-.053	.012	.022	-.014
Ev 3 Sh 9	-.018	.104	-.022	-.016	-.001	.012	.016
Ev 3 Sh 10	-.025	.128	-.041	-.016	-.003	.000	.039
ITV Sum	.004	-.005	.013	.003	.004	.002	-.019
ITV Ev 1 Sh 1	.003	-.011	.108	-.009	-.007	-.014	-.013
ITV Ev 1 Sh 2	-.014	-.009	.106	.008	.012	-.026	-.010
ITV Ev 1 Sh 3	.003	.002	.143	-.006	-.020	-.031	-.042
ITV Ev 1 Sh 4	.006	-.009	.171	-.001	.007	-.012	-.077
ITV Ev 1 Sh 5	-.004	-.021	.152	.007	-.008	-.007	-.041
ITV Ev 1 Sh 6	-.026	-.004	.151	.022	.017	-.032	-.010
ITV Ev 1 Sh 7	-.002	.002	.211	-.011	.016	-.015	-.108
ITV Ev 1 Sh 8	-.014	-.007	.146	.004	-.015	-.004	-.052
ITV Ev 1 Sh 9	.002	-.006	.131	-.004	-.004	.016	-.061
ITV Ev 1 Sh 10	-.003	-.008	.106	-.014	.000	-.004	-.019

Table 105 (Continued)

Variable	Factor Score Coefficients 1	2	3	4	5	6	7
ITV Ev 2 Sh 1	-.007	-.003	.014	.007	-.007	-.028	.108
ITV Ev 2 Sh 2	-.009	-.004	.023	-.001	-.008	-.001	.082
ITV Ev 2 Sh 3	-.009	-.012	.007	.011	-.023	-.055	.166
ITV Ev 2 Sh 4	.004	-.012	-.017	.004	.013	-.024	.165
ITV Ev 2 Sh 5	.005	-.015	-.035	-.008	.003	.025	.136
ITV Ev 2 Sh 6	.001	.001	-.045	-.001	-.010	-.018	.206
ITV Ev 2 Sh 7	.009	.002	-.041	-.024	.004	-.023	.209
ITV Ev 2 Sh 8	.003	-.012	.004	.010	-.016	-.000	.099
ITV Ev 2 Sh 9	-.014	.003	-.022	-.004	-.018	-.002	.197
ITV Ev 2 Sh 10	-.005	.007	-.023	-.003	.015	.000	.133
ITV Ev 3 Sh 1	-.019	.004	-.018	.002	.014	.160	-.007
ITV Ev 3 Sh 2	-.003	-.010	-.008	.003	-.000	.106	-.014
ITV Ev 3 Sh 3	-.004	.019	-.031	-.021	.011	.159	-.025
ITV Ev 3 Sh 4	-.018	-.009	-.020	.016	.029	.172	-.050
ITV Ev 3 Sh 5	.001	.001	-.027	-.014	.002	.119	.007
ITV Ev 3 Sh 6	-.022	.002	-.026	.020	-.019	.151	-.033
ITV Ev 3 Sh 7	.004	-.018	-.007	-.009	-.008	.132	-.019
ITV Ev 3 Sh 8	-.004	-.002	.002	-.010	.014	.174	-.056
ITV Ev 3 Sh 9	.003	-.002	-.004	-.019	-.014	.134	-.030
ITV Ev 3 Sh 10	-.002	.004	-.028	-.011	-.030	.161	-.036

To examine whether simpler composite variables could adequately represent the dimensions of school performance illustrated by the empirical factors, the researchers developed summary composite measures. Table 106 displays descriptive statistics on these composites, while Table 107 shows correlations between the composites and the empirical factors and the composite intercorrelations. The researchers computed reliability estimates for the Event totals in two different ways. First, we computed composite reliability using the communality estimates from the factor analysis. Second, we computed the average inter-shot correlation within each of the six Events, under the assumption that each shot replicates the others within the Event. The reliabilities based on communalities (.83 to .92) consistently exceeded those based on intercorrelations (.33 to .53).

Table 106
Descriptive Statistics for 11H ITV Composite Variables

Composite	Reliab[a]	Reliab[b]	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
TO[c]	.88	N/A	2.990	.030	-5.426	36.456	2.719	3.000
Ev 1 Total	.92	.53	494.045	160.979	-.427	-.297	.000	873.000
Ev 2 Total	.92	.53	577.903	139.545	-.822	1.302	29.000	935.000
Ev 3 Total	.91	.50	663.483	98.640	-.586	1.165	308.000	904.000
ITV Ev 1 Total	.86	.37	531.136	147.359	-.569	.291	.000	897.000
ITV Ev 2 Total	.86	.37	584.563	130.302	-.772	1.106	73.000	854.000
ITV Ev 3 Total	.83	.33	684.164	80.443	-.893	4.832	205.000	906.000

[a]These are composites based on communality estimates and the procedures described in the text.
[b]Mean inter-shot correlation within each Event.
[c]TO: (TO 1 + TO 2 + TO 3 + TO 4 + TO 5 + TO 7)/6

Table 107
Correlations Among 11H ITV Composites and Factors

	Factor												
Composite	1	2	3	4	5	6	7	TO	Ev 1	Ev 2	Ev 3	ITV Ev 1	ITV Ev 2
Factor 2	.01												
Factor 3	.01	.01											
Factor 4	.09	.04	-.00										
Factor 5	.01	.00	.00	.01									
Factor 6	.01	-.00	.04	.00	-.00								
Factor 7	.00	.01	.13	.09	.00	.08							
TO[a]	-.01	.03	-.03	.03	.79	.04	-.02						
Ev 1	.96	.15	.06	.29	-.00	.07	.05	.00					
Ev 2	.50	.26	.05	.87	.04	.07	.03	.05	.68				
Ev 3	.19	.97	.09	.19	.01	.03	.06	.03	.35	.46			
ITV Ev 1	.05	.07	.96	.04	-.01	.20	.29	-.03	.13	.12	.17		
ITV Ev 2	.07	.07	.47	.05	-.03	.30	.89	-.03	.15	.14	.17	.62	
ITV Ev 3	.06	.04	.20	.05	.02	.97	.21	.04	.14	.14	.10	.36	.46

[a]TO: (TO 1 + TO 2 + TO 3 + TO 4 + TO 5 + TO 7)/6

As seen in Table 107, the strong correlations (i.e., .79 to .97) between each composite and the corresponding factor it represents support the use of these summary criterion composites. The totals for Events 1 to 3 demonstrate moderate intercorrelations (.35 to .68), as do the totals for the ITV Events 1 to 3 (.36 to .62), indicating that these Event totals may be aggregated to form one grand total for Events 1 to 3 and a grand total for ITV Events 1 to 3.

To quantitatively assess this hypothesis, we factor analyzed the Event totals from Table 107. Table 108 displays the communalities, factor loadings, and factor score coefficients from this higher-order analysis. The factor loadings clearly indicate two factors consisting of the sum (or average) of the TOW tracking performance Event totals and the sum (or average) of the TOW simulator tracking Event totals.

We also computed Pearson correlation coefficients among these 2 factors and several composites, shown in Table 109. The average of the 3 Event totals correlates highest with Factor 1 (.93). The TOW Qualification score correlates .42 with Factor 1, suggesting that the TOW Qualification score provides a measure of maximal performance rather than typical performance. Similarly, the average ITV event total correlates highest (.96) with Factor 2, while the ITV Qualification score correlates only .54 with Factor 2.

Table 108
Communalities, Factor Loadings, and Factor Score Coefficients for 11H ITV Event Totals

Composite	Communality	Factor Loadings 1	Factor Loadings 2	Factor Score Coefficients 1	Factor Score Coefficients 2
Ev 1 Total	.517	.712	.096	.129	.008
Ev 2 Total	.900	.947	.054	.844	-.102
Ev 3 Total	.246	.474	.146	.050	.021
ITV Ev 1 Total	.493	.095	.696	.002	.232
ITV Ev 2 Total	.785	.094	.881	-.050	.695
ITV Ev 3 Total	.268	.113	.505	-.005	.113

Table 109
Correlations Among 11H ITV Composites and Higher-Order Factors

Composite[a]	TOW Qual[b]	TOW Avg	Factor1	ITV Qual	ITV Avg
TOW Avg[c]	.56				
Factor1[d]	.42	.93			
ITV Qual[e]	.10	.11	.07		
ITV Avg[f]	.16	.21	.13	.64	
Factor2[g]	.15	.12	.02	.54	.96

[a]These are composites based on the procedures described in the text.
[b]TOW Qual: TOW Qualification Score.
[c]TOW Avg: Average of TOW Events 1 through 3 Totals.
[d]Factor1: Factor 1 from analysis of Event Totals shown in Table 108.
[e]ITV Qual: ITV Qualification Score.
[f]ITV Avg: Average of ITV Events 1 through 3 Totals.
[g]Factor2: Factor 2 from analysis of Event Totals shown in Table 108.

Recommendations. For the HMMWV students, use the average of the totals for Events 1 to 3 and use the total for TOW Event 1. Also use the average of the prorated performance in the training objectives in the first part of training. For ITV students, use the average of the totals for Events 1 to 3, and the average of the totals for ITV Events 1 to 3. Also use the average of the prorated performance in the training objectives in the first part of training. (The Qualification scores provide measures of maximal performance for students in both programs.)

Tank Crewman (19K)

Description of Variables. RGI received student data that included an Armor Stakes score sheet and score sheets for three training modules or GATEs. Due to the inconsistency of the GATE sheets and the numerous GATE versions, both between and within classes, RGI only entered data from the Armor Stakes score sheet. (This decision had the support of Clint Walker at the Army Research Institute.)

The Armor Stakes is an end-of-course, comprehensive exam that includes tasks from GATEs I, II and III. The school divides the Armor Stakes test into five separate stations. The five Armor Stakes versions we received differed in station order and content. In Version A, the school administers the Weapons/Communications station first and the Nuclear, Biological and Chemical Defence (Nuc/Biol/Chem) station last. In Versions B, C, D and E the school administers the Nuc/Biol/Chem station first and the Weapons/Communications station last. The school administers the Maintenance station, Land Navigation/First Aid station, and Loader's Station (stations 2, 3 and 4, respectively) in the same order for all four versions of Armor Stakes. The content for all five stations differs only slightly between Versions A, B, C, D and E. The list below provides an overview of version similarities:

Order of Stations

Version A	Versions B, C, D & E
1. Weapons/Communications	1. Nuc/Biol/Chem
2. Maintenance	2. Maintenance
3. Land Navigation/First Aid	3. Land Navigation/First Aid
4. Loader's Station	4. Loader's Station
5. Nuc/Biol/Chem	5. Weapons/Communications

For all five Armor Stakes Versions, a station contains between 4 and 9 tasks. The school allows a soldier 2 attempts to pass each task, assigning a "GO" or "NO-GO" accordingly. The soldiers need to pass 75% of the tasks administered within a station, otherwise they must retake that station. For each Armor Stakes task, RGI assigned a 1 for passing on the first attempt, a 2 for passing on the second attempt, and a 3 for failing a task.

Throughout testing, the school administered Armor Stakes Versions A and B to different classes periodically. The school administered Armor Stakes Version C to a group of soldiers who completed GATE III on 04/07/91. The school did not indicate when these soldiers completed the Armor Stakes. In addition, the school administered Armor Stakes Version D to a group of soldiers on 05/28/91 and Version E to three soldiers on 05/25-05/26/91. The school indicated that their numerous revisions to the curricula accounted for the separate versions. All Armor Stakes tasks are performance tasks. The school records no Final School Grade (FSG) or measure of time spent in training. Student action codes contained the following categories of disenrollment: 1=Medical reason, 2=Failed to qualify, 3=Discharge, and 4=Unknown.

The school administered Armor Stakes Version A to the majority of soldiers. However, on some occasions, the school administered tasks 6, 7, and 8 from station 1 as tasks 4, 5, and 6, in station 4, respectively, and task 7 from station 4 as task 6 in station 1. The form variable in RGI's database (i.e., 1=most prevalent or 2=alternate administration order as described above) indicates which order the soldiers received tasks. The school indicated that equipment availability, weather conditions and instructors' discretion determine who received which tasks and their ordering. Students from Armor Stakes Versions A through E completed the tasks shown in Tables 110 through 114, respectively.

Table 110

19K Armor Stakes Version A

Task	Station
	Station 1-Weapons/Communications
Task 1:	Maintain an M9 pistol
Task 2:	Load an M16A1 rifle
Task 3:	Unload an M16A1 rifle
Task 4:	Correct malfunctions of an M16A1 rifle
Task 5:	Recognize friendly and threat vehicles and aircraft
Task 6:	Prepare/operate FM radio set
Task 7:	Operate intercommunication set AN/VIC-1 on a tracked vehicle
Task 8:	Send a radio message
	Station 2-Maintenance
Task 1:	Extinguish a fire on an M1/M1A1 tank
Task 2:	Vehicle maintenance (171-126-1012) Troubleshoot the M1/M1A1 tank using drivers control panel warning and caution lights
Task 3:	Vehicle maintenance (171-126-1017) Perform before-operations checks and services on an M1/M1A1 tank
Task 4:	Vehicle maintenance (171-126-1018) Perform during-operations checks and services on an M1/M1A1 tank
Task 5:	Vehicle maintenance (171-126-1019) Perform after-operations checks and services on an M1/M1A1 tank
Task 6:	Maintain operator's part of equipment record folder
	Station 3-Land Nav/First Aid
Task 1:	Identify terrain features on a map
Task 2:	Determine the grid coordinates of a point on a military map using the military grid reference system
Task 3:	Splint a suspected fracture
Task 4:	Put on a field or pressure dressing
	Station 4-Loader's Station
Task 1:	Prepare loader's station for operation on an M1/M1A1 tank (171-126-1023)
Task 2:	Prepare loader's station for operation on an M1/M1A1 tank (171-122-1017) Install/remove an M240 loader's machine gun on an M1/M1A1 tank
Task 3:	Clear and load an M240 machine gun
Task 4:	Load and unload the 105mm main gun on an M1/M1A1 tank
Task 5:	Secure loader's station on an M1/M1A1 tank (171-126-1024)
Task 6:	Secure loader's station on an M1/M1A1 tank (171-122-1017) Install/remove an M240 loader's machine gun on an M1/M1A1 tank
Task 7:	Clear a .50 cal M2 HB machine gun to prevent accidental discharge
Task 8:	Inspect 120mm ammunition for serviceability
	Station 5-Nuc/Biol/Chem
Task 1:	Put on, wear, remove and store an M25A1 protective mask with hood
Task 2:	Recognize and react to chemical or biological hazard
Task 3:	React to nuclear hazard
Task 4:	Decontaminate your skin and personal equipment Note: The school administers either tasks 5 and 6 or 7 and 8 from station 5 to the soldiers. However, the school periodically administers all four tasks to the soldiers. The school indicated that equipment availability, weather conditions and instructor's discretion determine who received which tasks.
Task 5:	Administer nerve agent antidote to self (self-aid)
Task 6:	Use M8 detector paper to detect chemical agent
Task 7:	Administer first aid to a nerve agent casualty (buddy-aid)
Task 8:	Use M9 detector paper to detect chemical agent

Table 111

19K Armor Stakes Version B

Task	Station
	Station 1-Nuc/Biol/Chem
Task 1:	Put on, wear, remove, and store your M25, M25A1 protective mask with hood
Task 2:	Recognize and react to chemical or biological hazard
Task 3:	React to nuclear hazard
Task 4:	Decontaminate your skin and personal equipment
	Note: The school administers either tasks 5 and 6 or tasks 7 and 8 from station 1 to most of the soldiers. However, the school periodically administers all four tasks to the soldiers. The school indicated that equipment availability, weather conditions and instructor's discretion determine who receives which tasks.
Task 5:	Administer nerve agent antidote to self (self-aid)
Task 6:	Use M-8 detection paper to ID chemical agents
Task 7:	Administer first aid to a nerve agent casualty (buddy-aid)
Task 8:	Use M-9 detection paper to ID chemical agents
	Station 2-Maintenance
Task 1:	Extinguish a fire on an M1/M1A1 tank
Task 2:	Troubleshoot the M1/M1A1 tank using drivers instrument control panel, warning and caution lights
Task 3:	Perform before-operations checks and services on an M1/M1A1 tank
Task 4:	Perform during-operations checks and service on an M1/M1A1 tank
Task 5:	Perform after-operations checks and service on an M1/M1A1 tank
Task 6:	Maintain operators part of equipment record folder
	Station 3-Land Nav/First Aid
Task 1:	ID terrain features on a map
Task 2:	Determine grid coordinates
	The school administered task 3 to some soldiers, in addition to tasks 1, 2, 4, and 5 from station 3. The school indicated that equipment availability, weather conditions and instructor's discretion determine who receives which tasks.
Task 3:	Estimate range
Task 4:	Splint a suspected fracture
Task 5:	Put on a field pressure dressing
	Station 4-Loader's Station
Task 1:	Inspect 120mm ammunition for serviceability
Task 2:	Prepare loader's station for operations on an M1/M1A1 tank
Task 3:	Install and remove loader's M240 machine gun on an M1/M1A1 tank
Task 4:	Clear and load an M240 machine gun
Task 5:	Load and unload the 105mm main gun on an M1/M1A1 tank
Task 6:	Secure loader's station on an M1/M1A1 tank
	The school administered task 7 from station 4 to most soldiers. The school indicated that equipment availability, weather conditions and instructor's discretion determine who receives which tasks.
Task 7:	Install and remove loader's M240 machine gun on an M1/M1A1 tank
Task 8:	Clear a .50 cal M2 HB machine gun
	Station 5-Weapons/Communications
Task 1:	Maintain an M9 pistol
Task 2:	Load, reduce stoppage and clear an M16A1/A2 rifle
Task 3:	Recognize friendly and threat armored vehicle and aircraft
Task 4:	Prepare/operate FM radio set
Task 5:	Operate intercom set AN/VRC-1 on a tracked vehicle
Task 6:	Send a radio message

Table 112

19K Armor Stakes Version C

Task	Station
	Station 1-Nuc/Biol/Chem
Task 1:	Put on, wear, remove and store M25 protective mask with hood
Task 2:	Recognize and react to chemical or biological hazard
Task 3:	React to a nuclear hazard
Task 4:	Decontaminate your skin and personal equipment
Task 5:	Use M-8 detector paper to ID chemical agent
Task 6:	Administer nerve agent antidote to self (self-aid)
Task 7:	Administer first aid to a nerve agent casualty (buddy-aid)
Task 8:	Use M9 paper to detect chemical agent
	Station 2-Maintenance
Task 1:	Extinguish a fire on an M1/M1A1 series tank
Task 2:	Troubleshoot the M1/M1A1 tank using drivers instrument control panel warning and caution lights
Task 3:	Perform before-operations checks and services on an M1/M1A1 tank
Task 4:	Perform during-operations checks and services on an M1/M1A1 tank
Task 5:	Perform after-operations checks and services on an M1/M1A1 tank
Task 6:	Maintain operators part of equipment record folder
	Station 3-Land Nav/First Aid
Task 1:	Identify terrain features on a map
Task 2:	Determine the grid coordinates
Task 3:	Splint a suspected fracture
Task 4:	Put on a field or pressure dressing
	Station 4-Loader's Station
Task 1:	Prepare loader's station for operations
Task 2:	Install/remove loader's M240 machine gun
Task 3:	Clear/load M240 machine gun
Task 4:	Load/unload 105mm main gun
Task 5:	Secure loader's station
Task 6:	Inspect 120mm ammunition
Task 7:	Clear M2 HB machine gun
	Station 5-Weapons/Communications
Task 1:	Maintain an M9 pistol
Task 2:	Unload and M16A1/M16A2 rifle
Task 3:	Recognize friendly and threat armored vehicles and aircraft
Task 4:	Prepare radio set AN/VRC-64 or AN/GRC-160 for operation
Task 5:	Operate radio set AN/VRC-64 or AN/GRC-160
Task 6:	Operate intercom set AN/VRC-1 on a tracked vehicle
Task 7:	Send a radio message

Table 113

19K Armor Stakes Version D

Task	Station
	Station 1-Nuc/Biol/Chem
Task 1:	Put on, wear, remove and store M25/M25A1
Task 2:	Recognize and react to chemical or biological hazard
Task 3:	React to a nuclear hazard
Task 4:	Decontaminate your skin and personal equipment
Task 5:	Administer nerve agent antidote to self (self-aid)
Task 6:	Use M8 paper to identify chemical agent
Task 7:	Administer first aid to a nerve agent casualty (buddy-aid)
Task 8:	Use M9 paper to detect chemical agent
	Station 2-Maintenance
Task 1:	Extinguish a fire on an M1/M1A1 series tank
Task 2:	Perform before, during, and after-operation checks and services on an M1/M1A1 series tank
Task 3:	Maintain operators part of equipment record folder
Task 4:	Troubleshoot the M1/M1A1 tank using drivers control panel warning and caution lights
	Station 3-Land Nav/First Aid
Task 1:	Identify terrain features on a map
Task 2:	Determine the grid coordinates of a point on a military map
Task 3:	Splint a suspected fracture
Task 4:	Put on a field or pressure dressing
	Station 4-Loader's Station
Task 1:	Prepare/operate FM radio sets
Task 2:	Send a radio message
Task 3:	Prepare loader's station for operation on an M1/M1A1 series tank
Task 4:	Clear and load an M240 machine gun
Task 5:	Load/unload the 105mm main gun on an M1/M1A1 series tank
Task 6:	Secure loader's station on an M1/M1A1 tank
Task 7:	Inspect 120mm ammunition for serviceability
Task 8:	Communicate using visual signaling techniques mounted
	Station 5-Weapons
Task 1:	Maintain an M9 pistol
Task 2:	Clear cal .50 M9 machine gun to prevent accidental discharge
Task 3:	Clear an M16A1/A2 rifle
Task 4:	Recognize friendly and threat armored vehicles and aircraft

Table 114

19K Armor Stakes Version E

Task	Station
	Station 1-Nuc/Biol/Chem
Task 1:	Put on, wear, remove and store M25/M25A1
Task 2:	Recognize and React to chemical or biological hazard
Task 3:	Decontaminate your skin and personal equipment
Task 4:	Administer nerve agent antidote to self (self aid)
Task 5:	Use M8 paper to identify chemical agent
Task 6:	Administer first aid to a nerve agent casualty (buddy aid)
Task 7:	Use M9 paper to detect chemical agent
	Station 2-Maintenance
Task 1:	Extinguish a fier on an M1/M1A1 tank
Task 2:	Perform before-operation checks and services on an M1/M1A1 tank
Task 3:	Perform during-operations checks and services on an M1/M1A1 tank
Task 4:	Perform after-operations checks and services on an M1/M1A1 tank
Task 5:	Maintain operators part of equipment record folder
	Station 3-Land Nav/First Aid
Task 1:	Identify terrain features on a map
Task 2:	Determine the grid coordinates of a point on a military map
Task 3:	Splint a suspected fracture
Task 4:	Put on a field or pressure dresing
	Station 4-Loader's Station
Task 1:	Prepare/operate FM radio sets
Task 2:	Send a radio message
Task 3:	Prepare loader's station for operation on an M1/M1A1 series tank
Task 4:	Clear and load and M240 machine gun
Task 5:	Load/unload the 105mm main gun on an M1/M1A1 series tank
Task 6:	Secure loader's station on an M1/M1A1 tank
Task 7:	Inspect 120mm ammunition for serviceability
Task 8:	Communicate using visual signaling techniques mounted
	Station 5-Weapons
Task 1:	Maintain an M9 pistol
Task 2:	Clear cal .50 M2 machine gun to prevent accidental discharge
Task 3:	Clear an M16A1/A2 rifle
Task 4:	Recognize friendly and threat armored vehicles and aircraft

Sample. The total 19K sample consisted of 1,529 subjects. The Versions had the following numbers of subjects: Version A Form 1: 869; Version A Form 2: 26; Version B: 390; Version C: 120; Version D: 121; Version E: 3.

Results and Discussion. We recoded each score so that soldiers who passed a task on the first trial received a score of 2; those who passed on the second trial received a score of 1; and those who failed the task received a score of 0. Initially, we factor analyzed the 19K variables at the task (item) level separately for Version A Form 1, and Versions B, C, and D, and we found strikingly different results for each analysis. Version A Form 1 (with 800 cases) demonstrated no clear factor pattern at all, with low communalities (range from .000 to .633, depending upon the number of factors extracted). Version B, with limited items from Stations 1, 4, and 5, showed a tendency for tasks within stations to group together. We were unable to factor analyze Version C, due to negative eigenvalues. Version D displayed no consistent or discernible pattern.

For the above reasons, we decided to group tasks by summing into logical content groupings, namely the stations. We also created a Communications category, because such items had appeared in either Weapons/Communications for Versions A, B, and C, or in Loader's Station for Version D. We did not separate Land Navigation/First Aid into two categories, since this grouping contained only four or five items, too small a number from which to develop two scales. This procedure resulted in a total of six categories. Further, we prorated scores by computing averages of available scores within a category so as to minimize the deletion of cases with missing data. As an indication of the extent of missing data, we computed a missing data function on the tasks which made up each category. Out of the total of 24 categories, 17 had some missing data. Over the 4 versions by category, the percentages of cases with missing data ranged from .1% to 40.3%, with a median of .8%. The percentages of cases missing more than 50% of the tasks within a category ranged from .2% to 40.3%, with a median of .8%. These small percentages suggest no systematic pattern to the missing data,

but given our prorating (or imputation) procedure, we could not investigate this possibility. Other researchers recommend other rules for handling missing data, such as a 50% rule, in which a case is excluded if the subject has fewer than half of the items which make up the scale.

Table 115 displays descriptive statistics on the aggregated variables for Version A Form 1, and Versions B, C, and D. We did not analyze Version A Form 2 and Version E, due to the small number of cases in each (26 and 3, respectively).

We computed the mean of the six composite variables computed above as a summary measure (Mean in Table 115), with descriptive statistics also shown in Table 115. We did not prorate this average score. This procedure resulted in excluding a case from the average if the case had a missing composite variable. Other researchers might want to prorate the average scores in addition to the composite variables. Researchers could also correlate the missing data function described above to the average scores to study the relationship of missing data to examinee performance.

Because the factor analyses differed across versions, we decided to conduct further tests to determine whether the soldiers in the various versions differed (i.e., came from different populations). First, we conducted multivariate analysis of variance (MANOVA) on the six composite scores. We found that the covariance matrices differed across the four versions ($F=22.24$, $p < .001$), as did the means ($F=50.05$, $p < .001$). Univariate F tests indicated that all six composite variables differed across versions.

Table 115
Descriptive Statistics for 19K Composite Variables

Composite	n	Rel[a]	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
Version A Form 1								
Communications	835	.02	1.967	.150	-4.891	25.512	.67	2.00
Weapons	844	.22	1.760	.293	-1.099	1.262	.00	2.00
Land Navigation/First Aid	850	.05	1.914	.209	-2.508	6.330	.75	2.00
Loader's Station	827	.06	1.783	.212	-.462	-.972	1.14	2.00
Maintenance	847	.08	1.950	.126	-2.699	8.975	1.00	2.00
Nuc/Biol/Chem	826	.07	1.856	.204	-1.418	2.577	.67	2.00
Mean	784	.34	1.873	.098	-1.081	2.314	1.33	2.00
Version B								
Communications	231	.14	1.921	.292	-4.670	24.901	.00	2.00
Weapons	385	.64	1.799	.354	-1.931	4.490	.00	2.00
Land Navigation/First Aid	232	.01	1.960	.150	-4.054	17.436	1.00	2.00
Loader's Station	390	.04	1.971	.110	-4.055	17.326	1.20	2.00
Maintenance	385	.12	1.926	.170	-4.698	42.905	.00	2.00
Nuc/Biol/Chem	388	.04	1.968	.106	-3.937	20.686	1.00	2.00
Mean	224	.45	1.891	.119	-1.475	3.993	1.28	2.00
Version C								
Communications	117	N/A	2.000	.000	N/A	N/A	2.00	2.00
Weapons	117	.00	1.977	.122	-5.194	25.409	1.33	2.00
Land Navigation/First Aid	117	.19	1.949	.152	-2.654	5.132	1.50	2.00
Loader's Station	117	.16	1.991	.065	-7.548	55.930	1.50	2.00
Maintenance	119	N/A	1.997	.031	-10.909	119.000	1.67	2.00
Nuc/Biol/Chem	119	.24	1.978	.081	-3.839	15.050	1.50	2.00
Mean	117	.35	1.983	.041	-2.650	7.120	1.79	2.00
Version D								
Communications	95	N/A	2.000	.000	N/A	N/A	2.00	2.00
Weapons	120	.53	1.558	.450	-.867	.058	.50	2.00
Land Navigation/First Aid	120	.06	1.554	.409	-1.047	1.594	.00	2.00
Loader's Station	118	.10	1.983	.081	-4.602	19.512	1.60	2.00
Maintenance	120	N/A	2.000	.000	N/A	N/A	2.00	2.00
Nuc/Biol/Chem	120	.02	1.892	.208	-1.960	3.447	1.00	2.00
Mean	93	.40	1.825	.121	-.765	-.073	1.50	2.00

Note. The variable "Mean" is (Communications + Weapons + Land Navigation/First Aid + Loader's Station + Maintenance + Nuc/Biol/Chem)/6

[a]These are composites based on the communality estimates and the procedures described in the text.

To explore possible reasons for the observed differences between versions, we attempted to examine ability as a cause. Since we had the soldiers' pre-enlistment ASVAB scores, we could use the ASVAB as a measure of ability and statistically adjust the composite and control for differences in ability. (Incidentally, in comparing the different versions (A1, B, C, and D) on the 10

ASVAB scores using MANOVA. the ASVAB correlation matrices did not differ across Versions ($F = .91$; $p = .79$, ns), but the 10 ASVAB means did differ across versions (approximate $F = 1.53$; $p = .03$).)

To partial out ability from the composite variables, we performed multivariate analysis of covariance on the six composite measures using the 10 ASVAB scores as covariates. The test for homogeneity of dispersion matrices indicated that the correlation matrices differed across versions ($F = 4.35$, $p < .001$). Generally, Version A had larger variances and covariances than the other versions. and since Version A had far more cases than any of the other versions, this finding produces a conservative alpha level for the test of means (Tabachnick & Fidell, 1983, p. 233). The means for the six composite scores did differ across the four Versions (approximate $F = 49.86$; $p < .001$). Univariate F-tests indicated that the means of all six composite variables differed significantly across versions. Of 35 individual pairwise comparisons among the means, 29 differed between versions at the $p<.05$ level.

These results indicate that, after controlling for ability, the soldiers differed in their performance on the composite tasks, both in level and pattern. These results implicate something other than soldiers' ability in producing the observed differences between versions (e.g., through an order effect), but we do not have enough information to fully answer this question. This suggests researchers should not combine scores from different versions.

However, to further evaluate the conclusion of differences between versions, we computed effect sizes as measures of the practical significance of the differences between the unadjusted means across versions. For example, comparing Versions A and B on the Communications variable ($M_A = 1.967$, $M_B = 1.921$), the effect size was .24. Cohen and Cohen (1977) say that .2 represents

a small effect size, .5 is medium, and .8 is large. For the total of 35 possible comparisons among the 19K versions, we found the following frequencies within these effect size categories: .00-.19 (9), .20-.49 (10), .50-.79 (8), and .80+ (8). These results show that 54% of the effect sizes fall below a value of .50. Thus, while the MANOVA tests indicate that the versions differ from one another in terms of statistical significance, the effect sizes suggest small magnitudes of the differences, in terms of practical significance.

To further attempt to obtain a useful summary measure of soldier performance, we submitted the six composite variables to factor analysis, separately for each version. Table 116 presents the communalities, factor loadings, and factor score coefficients for each version. We found a one-factor solution in each version. Table 117 displays correlations among the six composite scores, the mean composite score, and the factor score for each version. The separate composite measures do not relate highly to one another, though they correlate more highly with the mean composite measure. Table 117 also shows the correlations between the factor score and each composite score and the mean composite score. The correlations of the factor score with the composites ranged from .02 to .97, while the correlations of the factor score with the mean composite ranged from .81 to .97.

Table 116
Communalities, Factor Loadings, and Factor Score Coefficients for 19K Composite Variables

Composite	Communality	Factor Loading	Factor Score Coefficient
Version A Form 1			
Communications	.025	.159	.106
Weapons	.220	.469	.377
Land Navigation/First Aid	.052	.229	.152
Loader's Station	.063	.250	.167
Maintenance	.084	.289	.197
Nuc/Biol/Chem	.068	.260	.174
Version B			
Communications	.139	.373	.122
Weapons	.644	.803	.711
Land Navigation/First Aid	.012	.109	.027
Loader's Station	.040	.201	.093
Maintenance	.115	.338	.120
Nuc/Biol/Chem	.037	.192	.046
Version C			
Communications	N/A	N/A	N/A
Weapons	.000	.013	.008
Land Navigation/First Aid	.193	.439	.311
Loader's Station	.160	.400	.272
Maintenance	N/A	N/A	N/A
Nuc/Biol/Chem	.243	.493	.371
Version D			
Communications	N/A	N/A	N/A
Weapons	.527	.726	.666
Land Navigation/First Aid	.056	.238	.113
Loader's Station	.101	.318	.142
Maintenance	N/A	N/A	N/A
Nuc/Biol/Chem	.019	.138	.138

In summary, the limitations of the raw data include their essential dichotomous (pass/fail) nature at both the item level and at the overall performance level. At the item level, even measuring number of trials to passing, the variability was so limited that for all practical purposes, almost all students pass on the first trial. A student either graduates or fails to graduate, with no other recorded measure of overall school performance. However, the current research indicates that obtaining separate station scores to yield one summary measure may hold some degree of promise for validation research,

Table 117
Correlations Among the Composite Variables in 19K Versions

Composite	Comm	Weap	LN/FA	Load	Maint	N/B/C	Mean
Version A Form 1 (N = 784)							
Weapons	.03						
Land Navigation/First Aid	.08	.10					
Loader's Station	.14	.13	.04				
Maintenance	.05	.14	.07	.04			
Nuc/Biol/Chem	-.01	.14	.06	.04	.09		
Mean	.36	.65	.47	.50	.37	.47	
Factor	.26	.77	.38	.41	.47	.43	.97
Version B (N = 224)							
Weapons	.31						
Land Navigation/First Aid	-.06	.11					
Loader's Station	.21	.10	-.01				
Maintenance	.11	.27	.05	.10			
Nuc/Biol/Chem	-.03	.19	.13	-.01	.07		
Mean	.60	.82	.28	.36	.52	.29	
Factor	.45	.97	.13	.24	.41	.23	.93
Version C (N = 117)							
Weapons	N/A						
Land Navigation/First Aid	N/A	.09					
Loader's Station	N/A	-.02	.17				
Maintenance	N/A	N/A	N/A	N/A			
Nuc/Biol/Chem	N/A	-.05	.22	.20	N/A		
Mean	N/A	.54	.78	.42	N/A	.46	
Factor	N/A	.02	.67	.61	N/A	.75	.81
Version D (N = 93)							
Weapons	N/A						
Land Navigation/First Aid	N/A	.10					
Loader's Station	N/A	.28	.18				
Maintenance	N/A	N/A	N/A	N/A			
Nuc/Biol/Chem	N/A	.09	.21	-.09	N/A		
Mean	N/A	.74	.68	.34	N/A	.45	
Factor	N/A	.97	.28	.43	N/A	.18	.86

short of redesigning the 19K tests to have more desirable psychometric properties. Researchers also need to investigate differences among the versions.

Recommendations. Obtain separate station scores for Communications, Weapons, Land Navigation/First Aid, Loader's Station, Maintenance, and Nuc/Biol/Chem, and obtain the mean of these six scores to yield an overall summary measure. Do this for Version A Form 1 by itself. If an even larger sample size is desired, combine all available versions.

Air Force Schools

Apprentice Air Traffic Control Operator (27230)

Description of Variables. In January 1991, the school changed the curriculum from five blocks to six blocks, covering the same material but in a slightly different order. Students who enrolled prior to January 22, 1991 received the old curriculum; those who enrolled on or after that date received the present curriculum. The school broke the former Block I, National Air Traffic Training Program (NATTP), into two parts. The school formed the Federal Aviation Administration (FAA) computer-based instruction (CBI) component into Block VI, called Federal Control Tower Operator (CTO) Criteria. Finally, the school renamed the remainder of Block I Air Traffic Control Fundamentals.

Student training hours represent the number of hours a student takes to complete a block. Blocks III & V each include two training sections (a & b). The school also changed the training hours for the blocks, although the total hours stayed the same at 600:

	Block								
Curriculum	I	II	IIIa	IIIb	IV	Va	Vb	VI	Total
Former	155	55.5	77.5	40	73.5	40	158.5	---	600
Current	81.5	56	78.5	40	73.5	48	149	73.5	600

Students frequently spent more than these hours in training, sometimes up to twice as many hours in certain Blocks.

Table 118 describes the hours and test variables by Block. The school administers Written Knowledge Tests for Blocks I, II, IV, and VI (in the current curriculum); Performance Tests for Blocks III and V; and Quizzes for Training Blocks I, II, and IV. RGI entered test grades representing the scores attained

Table 11b
Descriptions of Air Traffic Control Operator (27230) Variables

Block	Title	Variables
I	National Air Traffic Training Program (former curriculum)	Hours. Written Test
I	Air Traffic Control Fundamentals (current curriculum)	Hours. Written Test
II	Control Tower Procedures	Hours. Written Test
IIIa	Control Tower Operation: Basic Tower Operation	Hours. Performance Test
IIIb	Control Tower Operation: Advanced Tower Operation	Hours. Performance Test
IV	Radar Approach Control Procedures	Hours, Written Test
Va	Radar Approach Control Operation: Basic Approach Control Operation	Hours. Performance Test
Vb	Radar Approach Control Operation: Advanced Approach Control Operation	Hours. Performance Test
VI	Federal Control Tower Operator Criteria (current curriculum)	Hours. Written Test

on only the first written knowledge tests for Training Blocks I, II, IV, & VI (for the current curriculum). Students who fail the exam retake it after remediation. For those passing the retest, the school assigns a grade of 70 and uses it in calculating the Final School Grade (FSG). In the former curriculum, the school calculated FSG as the mean of the three written knowledge tests. In the current curriculum, the school computes FSG as the mean of the four written knowledge tests.

Students receive performance scores for Training Blocks III and V. Since Blocks III and V each include two training sections, students receive a total of four performance scores. School instructors score the performance tests on a Satisfactory (S) or an Unsatisfactory (U) basis. For research purposes, researchers scored an "S" as a 1 and a "U" as a 0.

During Training Block IV, students receive quizzes covering specified course objectives, divided into 9 Progress Checks (abbreviated PC1 through PC9). Students receive either an "S" or a "U" on the quizzes, depending on whether they meet the passing score. The passing score (the standard) depends upon the number of items per quiz:

Number of items on quiz:	3	4	5	6	7	8	9	10	11	12	13	14	15
Standard:	2	3	3	4	5	5	6	7	8	9	9	10	11.

Students who fail a quiz retake it until they pass. For research purposes, we entered the sum of the "U"s on the initial quizzes for Training Block IV from the school's Summary Data Sheets (Form 667) into the database. This summary variable was Radar Approach Control Procedures (Block IV), with a valid range of digits from 0-29.

We also entered scores for Block IV quizzes (the number of correct responses per quiz). The school changed the curriculum during data collection. For this reason, the number of quizzes and the number of items per quiz differs. Students in class numbers through June 21, 1990 received up to 32 quizzes labeled 1a through 7c (Curriculum 1). Students in class numbers from June 22, 1990 through January 21, 1991 received up to 29 quizzes labeled 1a through 1ac (Curriculum 2). Students with class numbers from January 22, 1991 through September 29, 1991 received 23 quizzes labeled 1a through 1w (Curriculum 3). Students in class numbers from September 30, 1991 to the present receive 24 quizzes labeled 1a through 1x (Curriculum 4). However, Summary Data Sheets for both Curricula 3 and 4 list the quizzes as 1a through 1w. The school continued to use old summary sheets after September 29, 1991. For defining the class dates researchers used the entry date in the upper left-hand corner of the Form 156 instead of the current class number located in the upper-right hand corner of that form.

The school cannot provide specific Block IV quiz content for classes prior to 900625 (Curriculum 1). The school labeled the quizzes 1a through 7c on the Summary Data Sheets. However, researchers renamed the quizzes and entered them as they appeared on the Performance Checklists because they could not determine

the specific quiz content. The actual number of quizzes that the school administered may not match the number of quizzes specified in the summary sheet. The following list provides the number of items per quiz for Block IV, Curriculum 1:

PC1 Quiz 1 (7), PC2 Quiz 1 (11), PC2 Quiz 2 (7), PC2 Quiz 3 (10),
PC3 Quiz 1 (4), PC3 Quiz 2 (10), PC3 Quiz 3 (10),
PC4 Quiz 1 (10), PC4 Quiz 2 (10), PC4 Quiz 3 (6),
PC5 Quiz 1 (4), PC5 Quiz 2 (5), PC5 Quiz 3 (10),
PC6 Quiz 1 (9), PC6 Quiz 2 (4), PC6 Quiz 3 (6),
PC7 Quiz 1 (10), PC7 Quiz 2 (4), PC7 Quiz 3 (10), PC7 Quiz 4 (4),
PC8 Quiz 1 (10), PC8 Quiz 2 (4), PC8 Quiz 3 (4), PC8 Quiz 4 (10),
PC8 Quiz 5 (4), PC9 Quiz 1 (7), PC9 Quiz 2 (4), and PC9 Quiz 3 (10).

The school cannot provide specific Block IV quiz content for several quizzes used in classes 900628 through 910121 (Curriculum 2). The school labeled the quizzes 1a-1ac on the Summary Data Sheet. However, researchers renamed the quizzes and entered them as they appeared on the Performance Checklists because the researchers could not determine the specific quiz content. The actual number of quizzes that the school administered during this time period may not match the number of quizzes specified on the summary sheet. The following list provides the number of items per quiz for Block IV, Curriculum 2:

PC1 Quiz 1 (8), PC2 Quiz 1 (5), PC2 Quiz 2 (10), PC2 Quiz 3 (9),
PC3 Quiz 1 (4), PC3 Quiz 2 (9), PC3 Quiz 3 (10),
PC4 Quiz 1 (9), PC4 Quiz 2 (9), PC4 Quiz 3 (4),
PC5 Quiz 1 (3), PC5 Quiz 2 (4), PC5 Quiz 3 (4), PC5 Quiz 4 (10),
PC6 Quiz 1 (14), PC6 Quiz 2 (6),
PC7 Quiz 1 (6), PC7 Quiz 2 (10), PC7 Quiz 3 (4), PC7 Quiz 4 (4),

PC8 Quiz 1 (10), PC8 Quiz 2 (4), PC8 Quiz 3 (8),

PC9 Quiz 1 (4), PC9 Quiz 2 (9), and PC9 Quiz 3 (5).

The Block IV quiz information presented in Table 119 represents the curricula effective January 21, 1991 and September 30, 1991 (Curricula 3 and 4). The school added Quiz 1f into the curriculum in September 1991 and administered

Table 119

Block IV Quizzes by Progress Checks (PC) for 27230 School

PC	Quiz: Content (Number of Items)
1	**1a** (Curriculum 4 only): Identify procedures used to apply IFR separation. (9)
1	**1a** (Curriculum 3 only): Identify procedures used to apply IFR separation. (6)
1	**1b** (Curriculum 4 only): Identify procedures used to control IFR departures. (5)
2	**1c**: Identify procedures used to issue holding instructions. (6)
2	**1d**: Identify procedures used to control IFR arrivals. (9)
3	**1e**: Identify general radar procedures applied to aircraft. (5)
3	**1f** (Curriculum 4 only): Identify general principles about airport surveillance radar (ASR) indicators. (4)
3	**1f** (Curriculum 3), **1g** (Curriculum 4): Identify basic facts about electronic combat. (5)
3	**1g** (Curriculum 3), **1h** (Curriculum 4): Identify procedures used to assign beacon codes. (10)
4	**1h** (Curriculum 3), **1i** (Curriculum 4): Identify procedures used to establish radar identification. (9)
4	**1i** (Curriculum 3), **1j** (Curriculum 4): Identify procedures used to vector aircraft. (9)
4	**1j** (Curriculum 3), **1k** (Curriculum 4): Identify procedures used to apply radar separation. (11)
5	**1k** (Curriculum 3), **1l** (Curriculum 4): Identify procedures used to issue low altitude alerts. (4)
5	**1l** (Curriculum 3), **1m** (Curriculum 4): Identify procedures used to provide additional services. (8)
5	**1m** (Curriculum 3), **1n** (Curriculum 4): Identify services provided under terminal radar program. (10)
6	**1n** (Curriculum 3), **1o** (Curriculum 4): Identify procedures used to control radar arrivals. (14)
6	**1o** (Curriculum 3), **1p** (Curriculum 4): Identify procedures used to confirm aircraft altitudes. (4)
6	**1p** (Curriculum 3), **1q** (Curriculum 4): Identify the procedures used to transfer radar identification of aircraft. (12)
7	**1q** (Curriculum 3), **1r** (Curriculum 4): Identify procedures used to control radar arrivals. (15)
7	**1r** (Curriculum 3), **1s** (Curriculum 4): Identify procedures to control visual approaches. (4)
7	**1s** (Curriculum 3), **1t** (Curriculum 4): Identify general principles about contact approaches. (4)
8	**1t** (Curriculum 3), **1u** (Curriculum 4): Identify procedures used to control radar approaches. (5)
8	**1u** (Curriculum 3), **1v** (Curriculum 4): Identify procedures used to control ASR approaches. (8)
9	**1v** (Curriculum 3), **1w** (Curriculum 4): Identify general principles about precision approach radar (PAR) indicators. (4)
9	**1w** (Curriculum 3), **1x** (Curriculum 4): Identify procedures used to control PAR approaches. (8).

this quiz to students with class entry date numbers from 910930 to the present. The number in parentheses following each quiz description gives the number of items on the quiz.

Sample. The former curriculum contained 292 students, while the current curriculum contained 416 students, for a total of 708 students.

Results and Discussion. To examine the comparability of the two curricula, we tested the curricula on variables common to both by using MANOVA. The variables common to both curricula consisted of: hours for Blocks 2, 3A, 4, 5A, and 5b; written tests for Blocks 2 and 4; and performance tests for Blocks 3A, 5A, and 5B. The MANOVA indicated significant differences between the covariance matrices ($F = 5.130$, $p<.001$), as well as the means ($F = 11.742$, $p<.001$). Univariate F-tests indicated that 5 of the 10 variables differed between curricula at the $p<.05$ level.

To investigate ability as a possible determinant of the differences between the curricula, we conducted MANCOVA by partialling out ASVAB pre-enlistment scores. MANCOVA indicated that the covariance matrices still differed ($F = 2.132$, $p<.001$), as well as the means ($F = 10.469$, $p<.001$). Again, univariate F-tests indicated that 5 of the 10 variables differed between curricula at the $p<.05$ level. For these reasons, we treated the former and current curricula separately.

Table 120 shows descriptive statistics on variables in the former curriculum.

Factor analysis of the former curriculum variables (hours, written test scores, performance test scores, and quiz scores) indicated one strong factor, with an overall five-factor solution. Table 121 shows the communalities and factor loadings for the variables in the factor analysis, while Table 122 shows

factor score coefficients. Factor 1 shows a written test or FSG factor, although the hours for Block 4 receives a negative sign. The other four factors contrast each performance test with the corresponding hours variables (i.e., test 3A - hours for 3A). The results suggest that each performance block might constitute an independent dimension, also indicated by their low correlations with the other variables. Because the performance tests had a ceiling effect, as seen in Table 120, we hypothesized that the independence of the performance tests might have stemmed from a statistical artifact of the ceiling effect. The hours variables were not perfectly negatively correlated with their corresponding block tests. Thus. we also desired to determine if hours constituted a separate dimension. Finally, the quizzes did not appear to display any consistent patterns or relationships. We obtained essentially the same five-factor solution with the quizzes excluded as we did with them included. Thus, we left the quizzes in the factor scores, but since the quizzes referred only to Block 4, we did not develop composite variables from the quiz scores.

Table 120
Descriptive Statistics for 27230 Variables - Former Curriculum

Variable[a]	n	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
Block 1 (Nat. Air Traffic Training Prog.) Hours	292	158.863	21.599	.283	6.638	48.0	264.0
Block 2 (Control Tower Proc.) Hours	270	60.838	15.624	2.036	2.981	40.5	119.5
Block 3A (Basic Tower Op.) Hours	258	86.492	21.891	1.537	2.766	22.8	183.5
Block 3B (Advanced Tower Op.) Hours	240	39.385	4.881	3.150	25.114	24.0	72.0
Block 4 (Radar Approach Control Proc.) Hours	239	80.061	23.728	2.637	6.736	57.5	214.5
Block 5A (Basic Approach Control Op.) Hours	231	51.417	13.060	2.655	6.390	16.0	96.0
Block 5B (Advanced Approach Control Op.) Hours	226	150.265	19.699	1.796	8.457	74.5	268.5
Block 1 (Nat. Air Traffic Training Prog.) Written Test	283	78.972	8.025	- .348	- .129	52.0	97.0
Block 2 (Control Tower Proc.) Written Test	270	80.841	11.472	- .759	.687	38.0	100.0
Block 4 (Radar Approach Control Proc.) Written Test	239	80.075	10.346	- .722	.614	44.0	100.0
Block 3A (Basic Tower Op.) Perf. Test	245	.914	.281	-2.978	6.925	0.0	1.0
Block 3B (Advanced Tower Op.) Perf. Test	240	.983	.128	-7.599	56.206	0.0	1.0
Block 5A (Basic Approach Control Op.) Perf. Test	228	.873	.334	-2.253	3.102	0.0	1.0
Block 5B (Advanced Approach Control Op.) Perf. Test	227	.872	.335	-2.245	3.068	0.0	1.0
Progress Check 1 Quiz 1	177	7.209	.896	- .953	.300	4.0	8.0
Progress Check 2 Quiz 1	177	4.486	.700	-1.408	2.613	1.0	5.0
Progress Check 2 Quiz 2	177	8.859	1.181	-1.020	.666	5.0	10.0
Progress Check 2 Quiz 3	176	7.682	1.243	- .712	- .400	4.0	9.0
Progress Check 3 Quiz 1	177	3.706	.587	-2.042	3.795	1.0	4.0
Progress Check 3 Quiz 2	177	7.910	.955	- .609	- .334	5.0	9.0
Progress Check 3 Quiz 3	177	8.339	1.292	- .799	.596	4.0	10.0
Progress Check 4 Quiz 1	178	8.062	.928	- .983	.858	5.0	9.0
Progress Check 4 Quiz 2	178	7.916	1.089	-1.054	1.152	4.0	9.0
Progress Check 4 Quiz 3	177	2.960	1.222	- .850	- .546	0.0	4.0
Progress Check 5 Quiz 1	180	2.833	.388	-2.089	3.276	1.0	3.0
Progress Check 5 Quiz 2	180	3.806	.474	-2.773	8.979	1.0	4.0
Progress Check 5 Quiz 3	180	3.228	.944	-1.034	.226	0.0	4.0
Progress Check 5 Quiz 4	180	9.350	1.284	-2.314	5.406	3.0	10.0
Progress Check 6 Quiz 1	177	11.412	1.727	- .429	- .275	7.0	14.0
Progress Check 6 Quiz 2	170	5.153	.967	-1.067	.552	2.0	6.0
Progress Check 7 Quiz 1	181	5.182	.934	-1.158	1.133	2.0	6.0
Progress Check 7 Quiz 2	181	9.442	.812	-1.858	4.999	5.0	10.0
Progress Check 7 Quiz 3	180	2.983	.942	- .655	- .265	0.0	4.0
Progress Check 7 Quiz 4	180	3.422	.724	- .929	- .167	1.0	4.0
Progress Check 8 Quiz 1	179	8.626	1.267	-1.056	1.255	4.0	10.0
Progress Check 8 Quiz 2	179	3.095	.916	- .811	.055	0.0	4.0
Progress Check 8 Quiz 3	179	5.883	1.454	- .381	- .653	2.0	8.0
Progress Check 9 Quiz 1	175	3.583	.580	-1.222	1.472	1.0	4.0
Progress Check 9 Quiz 2	175	7.337	1.206	- .496	- .219	4.0	9.0
Progress Check 9 Quiz 3	175	4.537	.869	-1.814	2.408	1.0	5.0

[a]The Progress Checks are from Curriculum 2.

Table 121
Communalities and Factor Loadings for 27230 Variables - Former Curriculum

Variable[a]	Communality	Factor Loadings 1 FSG	2 Block 3A	3 Block 5B	4 Block 3B	5 Block 5A
Block 1 (Nat. Air Traffic Training Prog.) Hours	.237	.039	-.271	-.253	.110	-.293
Block 2 (Control Tower Proc.) Hours	.129	-.286	-.049	-.055	-.028	-.202
Block 3A (Basic Tower Op.) Hours	.322	-.041	-.515	-.029	.103	-.209
Block 3B (Advanced Tower Op.) Hours	.658	.019	.064	.119	.799	-.025
Block 4 (Radar Approach Control Proc.) Hours	.471	-.627	.153	.018	.005	-.232
Block 5A (Basic Approach Control Op.) Hours	.149	-.090	-.012	-.091	-.033	-.363
Block 5B (Advanced Approach Control Op.) Hours	.212	.028	-.039	-.455	-.011	-.045
Block 1 (Nat. Air Traffic Training Prog.) Written Test	.444	.388	.272	.323	.199	.276
Block 2 (Control Tower Proc.) Written Test	.417	.622	.087	.030	-.101	.106
Block 4 (Radar Approach Control Proc.) Written Test	.685	.794	.101	.146	.023	.150
Block 3A (Basic Tower Op.) Perf. Test	.297	-.094	.518	-.079	-.111	.038
Block 3B (Advanced Tower Op.) Perf. Test	.646	.013	-.092	.040	-.795	-.055
Block 5A (Basic Approach Control Op.) Perf. Test	.209	.035	-.064	-.003	.020	.451
Block 5B (Advanced Approach Control Op.) Perf. Test	.541	.005	-.031	.734	.033	-.015
Progress Check 1 Quiz 1	.274	.253	.230	.244	-.246	.192
Progress Check 2 Quiz 1	.234	.143	.455	-.010	.080	-.001
Progress Check 2 Quiz 2	.307	.093	.487	.196	.120	-.091
Progress Check 2 Quiz 3	.248	.112	.463	.137	.049	-.018
Progress Check 3 Quiz 1	.176	.110	.070	.392	-.068	.024
Progress Check 3 Quiz 2	.348	.217	.528	.020	.086	-.124
Progress Check 3 Quiz 3	.092	.271	.076	.002	-.002	-.113
Progress Check 4 Quiz 1	.271	.057	.360	.319	-.188	-.038
Progress Check 4 Quiz 2	.221	.162	.333	-.028	.066	.279
Progress Check 4 Quiz 3	.171	.256	.121	.179	.067	.233
Progress Check 5 Quiz 1	.149	.055	.028	.231	.072	-.295
Progress Check 5 Quiz 2	.189	.316	.024	.133	.027	-.266
Progress Check 5 Quiz 3	.256	.163	.432	.190	.040	-.072
Progress Check 5 Quiz 4	.103	.146	.054	.274	.008	.062
Progress Check 6 Quiz 1	.331	.241	.304	.414	.053	-.083
Progress Check 6 Quiz 2	.210	.256	.290	.178	.088	.145
Progress Check 7 Quiz 1	.114	.297	.148	-.027	.048	-.032
Progress Check 7 Quiz 2	.098	-.061	.182	.237	.045	-.050
Progress Check 7 Quiz 3	.231	.385	.175	.206	-.088	-.039
Progress Check 7 Quiz 4	.242	.454	.098	-.087	-.017	-.136
Progress Check 8 Quiz 1	.262	.365	.315	.150	.086	.020
Progress Check 8 Quiz 2	.205	.287	.261	.173	-.015	.157
Progress Check 8 Quiz 3	.254	.178	.367	.279	.018	.097
Progress Check 9 Quiz 1	.137	-.090	.203	.015	-.135	.264
Progress Check 9 Quiz 2	.190	.144	.338	.069	-.007	.224
Progress Check 9 Quiz 3	.082	-.047	-.001	.203	.080	.180

Note. n = 141.
[a]The Progress Checks are from Curriculum 2.

Table 122
Factor Score Coefficients for 27230 Variables - Former Curriculum

Variable[a]	Factor Score Coefficients 1 FSG	2 Block 3A	3 Block 5B	4 Block 3B	5 Block 5A
Block 1 (Nat. Air Traffic Training Prog.) Hours	.063	-.057	-.069	.033	-.124
Block 2 (Control Tower Proc.) Hours	-.014	.004	.029	-.044	-.066
Block 3A (Basic Tower Op.) Hours	.058	-.180	.039	.052	-.094
Block 3B (Advanced Tower Op.) Hours	-.032	-.031	.074	.474	-.038
Block 4 (Radar Approach Control Proc.) Hours	-.119	.143	.054	.002	-.120
Block 5A (Basic Approach Control Op.) Hours	.013	.022	-.030	-.020	-.163
Block 5B (Advanced Approach Control Op.) Hours	.042	.016	-.116	-.023	-.004
Block 1 (Nat. Air Traffic Training Prog.) Written Test	.055	.031	.099	.020	.159
Block 2 (Control Tower Proc.) Written Test	.234	-.034	-.027	-.083	.005
Block 4 (Radar Approach Control Proc.) Written Test	.472	-.078	.009	.022	.024
Block 3A (Basic Tower Op.) Perf. Test	-.047	.176	-.061	-.065	.012
Block 3B (Advanced Tower Op.) Perf. Test	.006	-.054	.099	-.439	-.064
Block 5A (Basic Approach Control Op.) Perf. Test	.019	-.044	.012	.015	.232
Block 5B (Advanced Approach Control Op.) Perf. Test	-.048	-.136	.493	-.021	-.034
Progress Check 1 Quiz 1	.009	.045	.034	-.069	.080
Progress Check 2 Quiz 1	-.013	.126	-.070	.029	-.018
Progress Check 2 Quiz 2	-.022	.147	.021	.039	-.077
Progress Check 2 Quiz 3	-.008	.120	.016	.012	-.039
Progress Check 3 Quiz 1	-.016	-.014	.121	-.023	-.001
Progress Check 3 Quiz 2	.028	.180	-.056	.021	-.114
Progress Check 3 Quiz 3	.019	.003	-.019	.031	-.076
Progress Check 4 Quiz 1	-.035	.083	.086	-.064	-.033
Progress Check 4 Quiz 2	-.010	.082	-.046	.017	.124
Progress Check 4 Quiz 3	.002	-.004	.030	.016	.089
Progress Check 5 Quiz 1	.013	.003	.078	-.002	-.125
Progress Check 5 Quiz 2	.066	-.022	.055	.013	-.150
Progress Check 5 Quiz 3	.032	.115	.028	-.012	-.077
Progress Check 5 Quiz 4	-.010	-.008	.038	.012	.016
Progress Check 6 Quiz 1	.023	.051	.123	-.001	-.098
Progress Check 6 Quiz 2	.020	.056	.040	-.009	.043
Progress Check 7 Quiz 1	.085	.017	-.007	.001	-.021
Progress Check 7 Quiz 2	-.035	.024	.066	.010	-.022
Progress Check 7 Quiz 3	.096	.021	.009	-.011	-.057
Progress Check 7 Quiz 4	.112	.023	-.061	-.006	-.116
Progress Check 8 Quiz 1	.064	.066	-.002	.001	-.015
Progress Check 8 Quiz 2	.043	.032	.022	.018	.041
Progress Check 8 Quiz 3	.006	.079	.050	.003	.029
Progress Check 9 Quiz 1	-.064	.054	.012	-.010	.108
Progress Check 9 Quiz 2	-.018	.081	-.027	-.014	.092
Progress Check 9 Quiz 3	-.002	-.018	.065	-.007	.085

[a]The Progress Checks are from Curriculum 2.

We computed several composite variables, including a measure for each of Factors 2 through 5. We defined the composites as follows: Block3A (standardized Block 3A test score - standardized Block 3A hours) for Factor 2,

Block5B (standardized Block 5B test score - standardized Block 5B hours) for Factor 3. Block3B (standardized Block 3B test score - standardized Block 3B hours) for Factor 4, and Block5A (standardized Block 5A test score - standardized Block 5A hours) for Factor 5. We also computed the sum of the hours for the 4 performance tests, the sum of the hours for the 3 written tests, the mean of the 4 performance test scores, and the mean of the 3 written test scores (Final School Grade computed from the initial test scores or FSG2). We also standardized each of the above 4 composites and added them to obtain a combined hours variable (the sum of the standardized hours for the performance tests and the standardized hours for the written tests) and a combined test variable (the sum of the standardized performance test sum and the standardized Final School Grade).

Table 123 shows descriptive statistics on these composites.

Table 123
Descriptive Statistics for 27230 Composite Variables - Former Curriculum

Composite	Reliability[a]	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
FSG	N/A	82.486	5.889	.019	-.646	70.000	97.000
FSG2[b]	.73	82.044	6.569	-.422	.255	58.000	97.330
Block3A[c]	.55	.000	1.781	-3.046	9.157	-8.650	1.660
Block5B[d]	.57	.000	1.625	-2.341	5.373	-7.030	2.550
Block3B[e]	.79	.000	1.869	-8.392	82.263	-18.280	3.740
Block5A[f]	.40	.000	1.702	-2.497	5.234	-6.260	1.420
Perf. Hours[g]	.42	324.531	31.318	1.295	1.904	240.000	444.000
Written Hours[h]	.39	290.204	28.971	1.635	4.502	204.000	425.000
Perf. Tests[i]	.32	.928	.118	-1.197	.073	.500	1.000

Note. N = 222
[a]These are composites based on communality estimates and the procedures described in the text.
[b]FSG2: Mean of initial test scores for Blocks 1, 2, and 4.
[c]Block3A: Standardized Block 3A test score - standardized Block 3A hours
[d]Block5B: Standardized Block 5B test score - standardized Block 5B hours
[e]Block3B: Standardized Block 3B test score - standardized Block 3B hours
[f]Block5A: Standardized Block 5A test score - standardized Block 5A hours
[g]Perf. Hours: Sum of hours for Blocks 3A, 3B, 5A, and 5B.
[h]Writ. Hours: Sum of hours for Blocks 1, 2, and 4.
[i]Perf. Tests: Mean of (initial) test scores for Blocks 3A, 3B, 5A, and 5B.

We also computed Pearson correlation coefficients for the composite variables. Table 124 displays correlations among the composites. FSG and FSG2 correlate .97, which offers no support for using initial test scores in computing FSG.

Table 124
Correlations Among 27230 Composites and Factors - Former Curriculum

Composite[a]	Fac1	Fac2	Fac3	Fac4	Fac5	FSG	FSG2
Factor 2	.07						
Factor 3	.04	.10					
Factor 4	-.00	.02	.01				
Factor 5	.06	.05	-.01	-.01			
FSG	.83	.26	.27	.04	.22		
FSG2[b]	.89	.21	.21	.03	.26	.97	
Block3A[c]	-.03	.67	-.03	-.13	.19	.11	.12
Test3A	-.10	.59	-.09	-.12	.05	.02	.02
Block5B[d]	-.04	.02	.83	.03	-.02	.14	.09
Test5B	-.02	-.02	.86	.03	-.06	.16	.11
Block3B[e]	-.01	-.10	-.06	-.97	-.02	-.09	-.08
Test3B	.02	-.11	.05	-.89	-.07	-.06	-.05
Block5A[f]	.07	-.03	.04	.03	.62	.10	.10
Test5A	.01	-.06	-.04	.02	.56	.04	.03
Perf. Hours[g]	-.03	-.37	-.34	.16	-.35	-.18	-.17
Writ. Hours[h]	-.59	-.05	-.12	.06	-.47	-.53	-.64
Perf. Tests[i]	-.05	.23	.53	-.19	.36	.14	.10

Composite[a]	Block3A	Test3A	Block5B	Test5B	Block3B	Test3B	Block5A	Test5A	Perf. Hours	Writ. Hours
Test3A	.88									
Block5B[d]	.06	-.05								
Test5B	-.01	-.09	.86							
Block3B[e]	-.00	-.01	-.06	-.08						
Test3B	-.03	-.02	-.01	-.03	.90					
Block5A[f]	-.02	-.10	-.02	-.07	-.00	-.03				
Test5A	-.03	-.09	-.07	-.12	.00	-.03	.86			
Perf. Hours[g]	-.58	-.30	-.56	-.28	-.12	-.07	-.35	-.17		
Writ. Hours[h]	-.15	-.05	-.00	-.05	-.01	.02	-.13	-.05	.16	
Perf. Tests[i]	.43	.40	.52	.56	.11	.14	.49	.56	-.48	-.09

Note. N = 140.
[a]These are composites based on communality estimates and the procedures described in the text.
[b]FSG2: Mean of initial test scores for Blocks 1, 2, and 4.
[c]Block3A: Standardized Block 3A test score - standardized Block 3A hours
[d]Block5B: Standardized Block 5B test score - standardized Block 5B hours
[e]Block3B: Standardized Block 3B test score - standardized Block 3B hours
[f]Block5A: Standardized Block 5A test score - standardized Block 5A hours
[g]Perf. Hours: Sum of hours for Blocks 3A, 3B, 5A, and 5B.
[h]Writ. Hours: Sum of hours for Blocks 1, 2, and 4.
[i]Perf. Tests: Mean of (initial) test scores for Blocks 3A, 3B, 5A, and 5B.

FSG2 correlates highest (.89) with Factor1, followed closely by FSG (.83). Block3A correlates highest (.67) with Factor2, followed by Test3A (.59). Test5B correlates highest (.86) with Factor3, followed closely by Block5B (.83). Block3B correlates highest (-.97) with Factor4, followed by Test3B (-.89). Similarly, Block5A correlates highest (.62) with Factor5, followed by Test5A (.56).

The high correlations of Block5B and Test5B with Factor3, and the high correlations of Block3B and Test3B with Factor4 indicate that these may indeed represent real independent dimensions of performance. The small differences in correlation between the full block measure (test score - hours) and the test score by itself suggest that the Test5B score and the Test3B score by themselves may represent Factor 3 and 4 adequately. Further, these two performance tests represent advanced aspects of the 27230 course: Test3B Advanced Tower Operation and Test5B Advanced Approach Control Operation. Moreover, Test3B and Test5B are independent of one another ($r = -.03$). The mean of Test3B and Test5B correlates .85 with Factor3 and -.20 with Factor4, indicating that researchers should not combine these two tests.

The low correlations between Block3A and Test3A with Factor2 and between Block5A and Test5A with Factor 5 indicate that these composites do not represent the factors well. None of the other composites (performance hours, written test hours, performance test mean) represented any factors well.

These correlational results suggest that researchers should use FSG, Test3B, and Test5B to describe 27230 school performance in the former curriculum.

Current Curriculum. Table 125 shows descriptive statistics on variables in the current curriculum. In the current curriculum, scores for all but 33 students were missing on the Block 3B (Advanced Tower Operation) Performance Test

due to failure of a simulator, thus, we did not further analyze this test or its corresponding hours. We also did not analyze Progress Check 3 Quiz 1a (Curriculum 3) (IFR separation), due to it having only 189 cases; Progress Check 3 Quiz 1a (Curriculum 4) (IFR separation) (only 23 cases); and Progress Check 3 Quiz 1f (Curriculum 4 only) (Airport Surveillance Radar) (only 24 cases).

We initially conducted factor analysis of all variables, including quizzes, in the current curriculum. While the scree test indicated one strong factor, none of the factor solutions provided clearly interpretable results. The only solution with a clear pattern of factor loadings involved analysis of just the hours, written tests, and performance tests, excluding the quizzes. Table 126 shows communalities and factor loadings for the five-factor solution, while Table 127 shows the factor score coefficients. The first factor involves the sum of the written tests except Block 2, minus Block 4 hours. The remainder of the factors are doublets consisting of the performance test scores minus the corresponding hours, and Block 2 test score minus Block 2 hours. This solution resembles that for the former curriculum, except for the written Test 2 standing as a factor and the lack of a factor for Block 3B. Accordingly, we developed composite variables to see if they would represent the obtained factors.

Table 125
Descriptive Statistics for 27230 Variables - Current Curriculum

Variable[a]	n	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
Block 1 (ATC Fundamentals) Hours	416	88.493	19.606	2.382	6.289	54.800	200.000
Block 2 (Control Tower Proc.) Hours	399	73.797	23.636	1.014	.164	20.500	152.000
Block 3A (Basic Tower Op.) Hours	355	81.899	21.767	.334	.653	12.000	153.500
Block 3B (Advanced Tower Op.) Hours	33	45.848	15.093	2.036	2.718	29.500	89.500
Block 4 (Radar Approach Control Proc.) Hours	340	76.222	16.753	3.687	13.419	63.500	175.500
Block 5A (Basic Approach Control Op.) Hours	326	50.458	11.397	2.672	6.061	34.000	96.000
Block 5B (Advanced Approach Control Op.) Hours	324	145.277	19.599	.344	5.424	42.600	237.000
Block 6 (Fed. Control Tower Oper. Criteria) Hours	321	31.126	6.418	.309	.275	18.000	53.000
Block 1 (ATC Fundamentals) Written Test	410	80.954	8.903	-.607	.944	40.000	100.000
Block 2 (Control Tower Proc.) Written Test	392	75.648	12.079	-.513	-.203	40.000	100.000
Block 4 (Radar Approach Control Proc.) Written Test	341	82.273	9.849	-.911	1.082	42.000	98.000
Block 6 (Fed. Control Tower Oper. Criteria) Written Test	315	86.733	5.450	-.424	-.176	70.000	99.000
Block 3A (Basic Tower Op.) Perf. Test	342	.965	.184	-5.076	23.902	.000	1.000
Block 3B (Advanced Tower Op.) Perf. Test	33	.879	.331	4.170	-2.433	.000	1.000
Block 5A (Basic Approach Control Op.) Perf. Test	327	.893	.310	-2.554	4.550	.000	1.000
Block 5B (Advanced Approach Control Op.) Perf. Test	322	.885	.319	-2.426	3.912	.000	1.000
PC 1 Quiz 1a (Curr. 3) (IFR separation)	189	7.910	1.030	-.822	.518	4.000	9.000
PC 1 Quiz 1a (Curr. 4) (IFR separation)	23	7.957	1.107	-1.229	1.193	5.000	9.000
PC 1 Quiz 1b (IFR departures)	212	5.024	1.150	-1.199	.948	1.000	6.000
PC 2 Quiz 1c (holding instructions)	223	5.614	.640	-1.739	3.029	3.000	6.000
PC 2 Quiz 1d (IFR arrivals)	223	8.103	1.050	-.986	.111	5.000	9.000
PC 3 Quiz 1e (general radar procedures)	235	4.528	.706	-1.459	1.702	2.000	5.000
PC 3 Quiz 1f (Curriculum 4 only) (ASR)	24	3.583	.584	-1.067	.295	2.000	4.000
PC 3 Quiz 1f (Curr 3), 1g (Curr 4) (electronic combat)	235	4.277	1.115	-1.272	.507	.000	5.000
PC 3 Quiz 1g (Curr 3), 1h (Curr 4) (beacon codes)	235	8.817	1.119	-.684	-.438	6.000	10.000
PC 4 Quiz 1h (Curr 3), 1i (Curr 4) (radar identification)	242	7.888	1.145	-1.184	1.203	4.000	9.000
PC 4 Quiz 1i (Curr 3), 1j (Curr 4) (vector aircraft)	242	7.921	1.130	-.959	.416	4.000	9.000
PC 4 Quiz 1j (Curr 3), 1k (Curr 4) (radar separation)	242	8.992	1.637	-.856	.453	3.000	11.000
PC 5 Quiz 1k (Curr 3), 1l (Curr 4) (low altitude alerts)	243	3.774	.457	-1.827	2.489	2.000	4.000
PC 5 Quiz 1l (Curr 3), 1m (Curr 4) (additional services)	243	7.160	.878	-.983	1.250	3.000	8.000
PC 5 Quiz 1m (Curr 3), 1n (Curr 4) (terminal radar prog.)	243	8.630	1.261	-.870	.593	4.000	10.000
PC 6 Quiz 1n (Curr 3), 1o (Curr 4) (radar arrivals)	242	12.930	1.369	-1.369	1.581	7.000	14.000
PC 6 Quiz 1o (Curr 3), 1p (Curr 4) (aircraft altitudes)	242	3.434	.750	-1.143	.560	1.000	4.000
PC 6 Quiz 1p (Curr 3), 1q (Curr 4) (transfer radar ID)	242	10.223	1.771	-1.224	1.575	3.000	12.000
PC 7 Quiz 1q (Curr 3), 1r (Curr 4) (radar arrivals)	245	13.865	1.139	-.958	.901	9.000	15.000
PC 7 Quiz 1r (Curr 3), 1s (Curr 4) (visual approaches)	245	3.102	.920	-.905	.352	.000	4.000
PC 7 Quiz 1s (Curr 3), 1t (Curr 4) (contact approaches)	245	3.522	.644	-1.199	1.119	1.000	4.000
PC 8 Quiz 1t (Curr 3), 1u (Curr 4) (radar approaches)	245	4.016	.864	-.725	.205	1.000	5.000
PC 8 Quiz 1u (Curr 3), 1v (Curr 4) (ASR approaches)	245	6.318	1.247	-.367	-.606	3.000	8.000
PC 9 Quiz 1v (Curr 3), 1w (Curr 4) (PAR indicators)	246	3.569	.600	-1.067	.128	2.000	4.000
PC 9 Quiz 1w (Curr 3), 1x (Curr 4) (PAR approaches)	246	6.439	1.165	-.429	-.368	3.000	8.000

[a]PC: Progress Check

Table 126
Communalities and Factor Loadings for 27230 Variables - Current Curriculum

Variable	Communality	Factor Loadings 1 FSG	2 Block 5A	3 Block 2	4 Block 5B	5 Block 3A
Block 1 (ATC Fundamentals) Hours	.106	-.126	.037	-.013	.031	-.296
Block 2 (Control Tower Proc.) Hours	.435	-.154	.036	-.636	-.028	-.067
Block 3A (Basic Tower Op.) Hours	.271	-.020	.201	-.105	-.166	-.438
Block 4 (Radar Approach Control Proc.) Hours	.264	-.500	-.062	-.064	.041	.067
Block 5A (Basic Approach Control Op.) Hours	.737	.021	.856	-.026	-.007	-.059
Block 5B (Advanced Approach Control Op.) Hours	.307	-.027	.079	-.145	-.522	-.076
Block 6 (Fed. Control Tower Oper. Criteria) Hours	.033	.013	.039	-.108	-.108	-.092
Block 1 (ATC Fundamentals) Written Test	.317	.376	-.038	.205	.124	.341
Block 2 (Control Tower Proc.) Written Test	.630	.216	-.012	.749	.148	.008
Block 4 (Radar Approach Control Proc.) Written Test	.761	.840	-.026	.163	.072	.150
Block 6 (Fed. Control Tower Oper. Criteria) Written Test	.324	.418	-.087	.163	.164	.298
Block 3A (Basic Tower Op.) Perf. Test	.245	-.032	.037	-.015	.101	.482
Block 5A (Basic Approach Control Op.) Perf. Test	.593	.012	-.751	.048	.132	.094
Block 5B (Advanced Approach Control Op.) Perf. Test	.613	.086	-.021	-.008	.771	.099

Note. N = 311.

Table 127
Factor Score Coefficients for 27230 Variables - Current Curriculum

Variable	Factor Score Coefficients 1 FSG	2 Block 5A	3 Block 2	4 Block 5B	5 Block 3A
Block 1 (ATC Fundamentals) Hours	-.036	-.008	.006	.039	-.164
Block 2 (Control Tower Proc.) Hours	.045	-.018	-.344	.049	-.019
Block 3A (Basic Tower Op.) Hours	.066	.014	-.011	-.034	-.291
Block 4 (Radar Approach Control Proc.) Hours	-.137	-.004	.031	.036	.090
Block 5A (Basic Approach Control Op.) Hours	.017	.630	-.000	.058	.039
Block 5B (Advanced Approach Control Op.) Hours	.046	-.003	-.032	-.236	.011
Block 6 (Fed. Control Tower Oper. Criteria) Hours	.030	-.003	-.030	-.015	-.044
Block 1 (ATC Fundamentals) Written Test	.049	.000	.045	-.005	.199
Block 2 (Control Tower Proc.) Written Test	-.035	.012	.602	.056	-.113
Block 4 (Radar Approach Control Proc.) Written Test	.754	-.010	-.102	-.033	-.003
Block 6 (Fed. Control Tower Oper. Criteria) Written Test	.108	.004	-.005	.012	.157
Block 3A (Basic Tower Op.) Perf. Test	-.086	.041	-.016	-.010	.343
Block 5A (Basic Approach Control Op.) Perf. Test	-.006	-.348	-.013	.038	.007
Block 5B (Advanced Approach Control Op.) Perf. Test	.008	.034	-.100	.662	-.045

We computed the following composite variables: FSG2, Block5A (standardized Test5A - standardized Block5A hours), Block2 (standardized Test2 - standardized Block2 hours), Block5B (standardized Test5B - standardized Block5B hours), and Block3A (standardized Test3A - standardized Block3A hours). We also computed the

sum of the hours for the 3 performance tests (3A, 5A, 5B), the sum of the hours for the 4 written tests (1, 2, 4, and 6), the mean of the 3 performance test scores, and the mean of the 4 written test scores (Final School Grade, computed from the initial test scores, FSG2). We also standardized each of the above composites and added them to obtain a combined hours variable (the sum of the standardized hours for the performance tests and the standardized hours for the written tests) and a combined test variable (the sum of the standardized performance test sum and the standardized Final School Grade). Table 128 shows descriptive statistics for these composites.

Table 129 displays correlations among the composites. Since FSG and FSG2 correlate .97, this offers no support for using initial test scores to compute FSG. FSG and FSG2 each correlate .74 with Factor1, a correlation no doubt attenuated by the low loading of Test2 on the factor. Block5A correlates highest

Table 128
Descriptive Statistics for 27230 Composite Variables - Current Curriculum

Composite	Reliability[a]	Mean	Std Dev	Skewness	Kurtosis	Minimum	Maximum
FSG	N/A	83.642	5.115	.336	-.460	72.000	98.000
FSG2[b]	.76	82.986	5.658	.060	-.239	66.750	97.500
Block5A[c]	.80	.000	1.814	-3.054	8.493	-7.840	1.860
Block2[d]	.69	.000	1.736	-1.110	.563	-5.990	2.880
Block5B[e]	.62	.000	1.692	-1.935	5.277	-7.960	5.800
Block3A[f]	.42	.000	1.608	-3.321	15.458	-9.160	2.240
Perf. Hours[g]	.58	276.222	34.316	.924	2.124	159.600	404.500
Written Hours[h]	.35	256.453	28.120	1.628	2.820	209.100	380.500
Perf. Tests[i]	.57	.932	.155	-2.219	4.277	.330	1.000

Note. n = 307
[a]These are composites based on communality estimates and the procedures described in the text.
[b]FSG2: Mean of initial test scores for Blocks 1, 2, 4, and 6.
[c]Block5A: Standardized Block 5A Performance Test - standardized Block 5A hours
[d]Block2: Standardized Block 2 Written Test - standardized Block 2 hours
[e]Block5B: Standardized Block 5B Performance Test - standardized Block 5B hours
[f]Block3A: Standardized Block 3A Performance Test - standardized Block 3A hours
[g]Perf. Hours: Sum of hours for Blocks 3A, 5A, and 5B.
[h]Writ. Hours: Sum of hours for Blocks 1, 2, 4, and 6
[i]Perf. Tests: Mean of initial test scores for Blocks 3A, 5A, and 5B.

Table 129
Correlations Among 27230 Composites and Factors - Current Curriculum

Composite[a]	Fac 1	Fac 2	Fac 3	Fac 4	Fac 5	FSG	FSG2
Factor 2	.01						
Factor 3	.11	-.01					
Factor 4	.01	-.00	.02				
Factor 5	.15	-.06	.02	.11			
FSG	.74	-.03	.53	.15	.39		
FSG2[b]	.74	-.04	.63	.17	.35	.97	
Block5A[c]	-.00	-.99	.03	.07	.10	.07	.07
Test5A	.02	-.84	.05	.15	.12	.11	.11
Block2[d]	.23	-.02	.97	.08	.05	.57	.67
Test2	.24	.01	.92	.14	-.02	.62	.71
Block5B[e]	.06	-.05	.07	.95	.12	.19	.21
Test5B	.07	.00	-.06	.95	.11	.13	.15
Block3A[f]	-.01	-.08	.05	.18	.85	.19	.17
Test3A	-.04	.11	-.06	.08	.71	.08	.06
Perf. Hours[g]	-.02	.47	-.18	-.48	-.47	-.25	-.25
Written Hours[h]	-.41	.02	-.58	.03	-.21	-.43	-.50
Perf. Tests[i]	.04	-.48	-.03	.72	.37	.17	.18

Composite[a]	Block5A	Test5A	Block2	Test2	Block5B	Test5B	Block3A	Test3A	Perf. Hrs	Writ. Hrs
Test5A	.91									
Block2[d]	.05	.07								
Test2	.02	.06	.87							
Block5B[e]	.10	.14	.13	.15						
Test5B	.06	.14	.03	.05	.85					
Block3A[f]	.11	.11	.07	.07	.17	.14				
Test3A	-.06	-.05	-.02	-.05	.08	.10	.80			
Perf. Hours[g]	-.47	-.38	-.19	-.20	-.60	-.31	-.60	-.17		
Written Hours[h]	-.05	-.04	-.68	-.43	-.06	-.02	-.10	-.05	.12	
Perf. Tests[i]	.57	.68	.06	.05	.64	.75	.42	.36	-.48	-.05

Note. n = 307
[a]These are composites based on communality estimates and the procedures described in the text.
[b]FSG2: Mean of initial test scores for Blocks 1, 2, 4, and 6.
[c]Block5A: Standardized Block 5A Performance Test - standardized Block 5A hours
[d]Block2: Standardized Block 2 Written Test - standardized Block 2 hours
[e]Block5B: Standardized Block 5B Performance Test - standardized Block 5B hours
[f]Block3A: Standardized Block 3A Performance Test - standardized Block 3A hours
[g]Perf. Hours: Sum of hours for Blocks 3A, 5A, and 5B.
[h]Writ. Hours: Sum of hours for Blocks 1, 2, 4, and 6
[i]Perf. Tests: Mean of initial test scores for Blocks 3A, 5A, and 5B.

(-.99) with Factor2, followed by Test5A (-.84). Block2 correlates highest (.97) with Factor3, followed closely by Test2 (.92). Both Block5B and Test5B correlate .95 with Factor4, followed by the mean of the performance tests (.72). Block3A correlates highest (.85) with Factor5, followed by Test3A (.71).

These results suggest that FSG and the above test scores alone may represent the dimensions of performance. However, since FSG contains Test2 and FSG and Test2 correlate .62, FSG and Test2 do not constitute independent dimensions. These findings support using FSG as an indicator of performance on knowledge tests but suggest using separate indicators for performance on each available performance test.

Recommendations. Researchers should treat the two curricula separately. In the former curriculum, in addition to FSG, use performance test 3B and performance test 5B. In the current curriculum, in addition to FSG, use performance test 3A, performance test 5A, and performance test 5B.

Apprentice Personnel Specialist (73230)

Description of Variables. The Air Force Apprentice Personnel Specialist (APS) (73230) school consists of 7 blocks of instruction. The 7 blocks are: Block I - Orientation, Block II - Introduction to Personnel and General Administrative Procedures, Block III - Unit Orderly Room and Customer Assistance Section, Block IV - Quality Force Section, Block V - Career Progression Section, Block VI - Personnel Utilization Section, and Block VII - Personnel Data System. Student training hours represent the number of hours a student takes to complete a block. Students have training hours recorded for each of the 7 blocks. Students who disenroll from class receive a status variable which describes the category of disenrollment (see Appendix B).

Typing Tests: Students must type a minimum of 15 words per minute (WPM) with no more than three errors to pass the Block I By-Pass test and to by-pass the 6 additional typing tests in Blocks I-VI. Those trainees who fail to type 15 WPM with three or fewer errors take typing tests throughout the course until they meet those standards. (Since few people had to take extra typing tests, the researchers did not include these later scores in the analyses.) Students must attain or retain a minimum typing speed of 15 WPM with no more than five errors to pass the final typing test and the Air Force Performance Test (AFPT) 70.

Written Tests: Test grades represent the grades attained on the final exams for Blocks II-VII. The Block V exam has 25 items; all the other exams have 40 items. If students fail the final exam, the school retests them. The students need to attain a minimum grade of 70% to pass, except on the Block V exam where they need a 72%. Some students receive an initial test grade lower than the minimum passing grade. These students must retake the block test. All students get a passing score on the first retake; however, the block grade for

these students always equals the minimum passing score. The school computes the Final School Grade (FSG) as the arithmetic average (mean) of the block grades (Blocks II through VII), while we computed FSG using the initial test scores (FSG2). The database included test grades for Blocks II through VII. The school measures all test and block grades and FSG on a scale of 0-100.

Quizzes: Students must take from 7 to 18 quizzes before taking the final exam for a block. The school scores the quizzes on a Satisfactory (S)/Unsatisfactory (U) basis. If students fail the first block exam, they repeat the quizzes and take a block retest. Numbers for quiz data represent total number of "U"s on the first attempt. The quiz variables consist of the initial and retest quizzes shown in Table 130. Since the researchers entered the number of "U"s into the database, for the analyses we recoded these data to reflect the number of "S"s using the formula: number of "S"s = number of quizzes - number of "U"s. Thus, for example, in Block II: number of "S"s = 17 - number of "U"s.

Table 130

Apprentice Personnel Specialist Initial and Retest Quiz Variables

Block	Quiz	No. of Quizzes	Block	Quiz	No. of Quizzes
II	Initial	17	V	Initial	7
II	Retest	17	V	Retest	7
III	Initial	18	VI	Initial	16
III	Retest	18	VI	Retest	16
IV	Initial	12	VII	Initial	13
IV	Retest	12	VII	Retest	13

Sample. We analyzed 22 variables after eliminating all the retest quiz variables, since they had little or no variability and values only for a very small number of cases (between 6 and 68 cases). We did not factor analyze Final School Grade since it consists of the weighted test scores. From the initial sample of 385, the final sample analyzed consisted of 297 cases with no missing data on any of the 22 variables listed in Table 131.

Results and Discussion. Factor analysis indicates three factors. Table 132 shows the communalities, rotated factor loadings, and factor score coefficients. The primary factor (Factor 1) contrasts training hours with test scores [(hours for Blocks II through VII) - (test scores for Blocks II, III, IV,

Table 131
Descriptive Statistics for 73230 Variables

Variable	Mean	Std Dev	Skew	Kurtosis	Minimum	Maximum
Block I By-Pass Test (WPM)	28.960	9.615	1.158	1.719	15.000	68.000
Final Typing Test (WPM)	32.380	8.555	1.593	4.071	20.000	72.000
AFPT70 (WPM)	31.428	8.103	1.508	3.542	20.000	72.000
Block I Hours	5.951	.149	-2.725	5.461	5.500	6.000
Block II Hours	40.638	10.485	1.197	4.069	18.000	92.000
Block III Hours	32.047	13.852	1.378	1.852	12.500	90.500
Block IV Hours	24.634	10.746	1.800	4.467	7.300	77.000
Block V Hours	20.597	8.863	1.733	5.370	7.300	71.800
Block VI Hours	31.518	11.933	1.470	3.013	12.500	84.000
Block VII Hours	23.455	6.949	1.088	1.973	10.000	54.000
Block II Test	84.613	8.274	-.208	-.404	60.000	100.000
Block III Test	76.747	10.445	-.160	-.231	45.000	100.000
Block IV Test	80.916	10.635	-.590	.231	45.000	100.000
Block V Test	81.650	9.711	-.448	-.104	48.000	100.000
Block VI Test	80.455	9.179	-.239	-.208	50.000	100.000
Block VII Test	85.721	7.726	-.440	-.250	63.000	100.000
Block II Initial Quiz	15.485	1.445	-.896	.543	10.000	17.000
Block III Initial Quiz	17.081	.990	-1.110	1.317	13.000	18.000
Block IV Initial Quiz	11.401	.796	-1.373	1.727	8.000	12.000
Block V Initial Quiz	6.620	.647	-1.695	2.459	4.000	7.000
Block VI Initial Quiz	15.027	1.023	-.969	.537	11.000	16.000
Block VII Initial Quiz	12.273	.868	-1.340	2.396	8.000	13.000

Note: N = 297

Table 132
Communalities, Factor Loadings, and Factor Score Coefficients for 73230 Variables

Variable	Communality	Factor Loadings			Factor Score Coefficients		
		Fac 1: Hours	Fac 2: FSG	Fac 3: WPM	Fac 1: Hours	Fac 2: FSG	Fac 3: WPM
Block I By-Pass Test	.793	-.099	.109	.878	-.013	-.005	.137
Final Typing Test	.946	-.062	.114	.964	.073	.061	.600
AFPT70	.888	-.109	.082	.933	-.061	-.092	.289
Block I Hours	.007	.021	.002	.080	-.001	-.002	.000
Block II Hours	.459	.650	-.155	-.111	.179	.066	.013
Block III Hours	.537	.725	-.105	.031	.276	.127	.001
Block IV Hours	.556	.729	-.155	-.020	.283	.120	.021
Block V Hours	.378	.603	-.120	-.010	.090	.006	-.019
Block VI Hours	.496	.697	-.097	.040	.240	.088	.032
Block VII Hours	.387	.571	-.246	.015	.100	-.026	.017
Block II Test	.453	-.472	.479	.037	-.055	.132	.000
Block III Test	.438	-.478	.457	.014	-.031	.142	-.029
Block IV Test	.439	-.409	.513	.095	-.014	.170	.102
Block V Test	.233	-.161	.444	.097	-.015	.098	-.026
Block VI Test	.273	-.360	.378	-.002	-.010	.081	-.008
Block VII Test	.330	-.171	.549	-.001	.020	.165	-.022
Block II Initial Quiz	.394	-.255	.573	.010	.035	.208	-.020
Block III Initial Quiz	.236	-.161	.457	-.039	.021	.118	-.018
Block IV Initial Quiz	.240	-.103	.473	.077	.038	.144	-.009
Block V Initial Quiz	.117	.016	.328	.096	.028	.082	-.009
Block VI Initial Quiz	.274	-.118	.509	.026	.042	.164	-.017
Block VII Initial Quiz	.204	-.012	.450	.022	.060	.145	-.003

Note. N = 297

plus VI)]. The second factor (Factor 2) defines a "test plus quiz" factor (the sum of all test scores plus all quiz scores), while the third (Factor 3) defines a "typing" or WPM factor (the sum of Block I By-Pass Test, the Final Typing Test, and AFPT70).

Table 133 displays descriptive statistics on composite variables derived from the factors. The sum of training hours and total WPM each had relatively large standard deviations, indicating large individual differences among the students. The distributions of the criteria show only a slight positive skew.

Table 134 shows the correlations among the factors and composites. Since FSG and FSG2 correlate .98, this offers no support for using initial test scores to compute FSG.

Table 133
Descriptive Statistics for 73230 Composite Variables

Composite	Reliability[a]	Mean	Std Dev	Skew	Kurtosis	Minimum	Maximum
Hours[b]	.84	172.889	47.121	.644	.460	71.100	349.000
FSG	N/A	82.512	5.672	.558	-.098	70.000	100.000
FSG2[c]	.77	81.684	6.391	.281	-.243	66.333	99.667
WPM[d]	.95	30.923	8.375	1.445	3.237	18.333	70.333

[a]These are composites based on communality estimates and the procedures described in the text.
[b]Hours: Sum of Hours for Blocks II through VII
[c]FSG2: (Sum of Initial Test Scores for Blocks II through VII)/6
[d]WPM: (By-Pass + Final + AFPT70)/3

Table 134
Correlations Among 73230 Composites and Factors

Composite	Factor 1	Factor 2	Factor 3	Hours	FSG	FSG2
Factor 2	-.13					
Factor 3	-.00	.03				
Hours[a]	.98	-.21	-.01			
FSG	-.50	.80	.08	-.52		
FSG2[b]	-.56	.79	.06	-.57	.98	
WPM[c]	-.10	.12	.98	-.11	.20	.18

[a]Hours: Sum of Hours for Blocks II through VII
[b]FSG2: (Sum of Initial Test Scores for Blocks II through VII)/6
[c]WPM: (By-Pass + Final + AFPT70)/3

Hours (the unit-weighted sum of student training hours for Blocks II through VII) correlates highest (.98) with Factor 1. Such a high correlation between the unit-weighted sum of training hours with the empirically defined Factor 1 supports use of the simpler unit-weighted sum of training hours. The sum of standardized training hours for Blocks II through VII and empirical Factor 1 correlate .97 (not shown in Table 134). These two correlations actually exceed those for the unit-weighted hours-test score contrast with the empirical Factor 1. Using raw scores, the unit-weighted hours-test score contrast and Factor 1 correlate .94, and using standard scores, they correlate .91 (not shown in Table 134). All these results support using just the sum of training hours for Blocks II through VII as a meaningful criterion dimension.

FSG shows an inverse relationship both with Factor 1 (r=-.50) and with the sum of hours for Blocks II through VII (r=-.52). This measure of training hours indicates that students who spent more time in training tended to have lower FSGs; weaker students needed to practice more to get through the APS school program, while students with higher FSGs spent less time in training.

Factor 2 consists of the sum of the test grades plus the sum of the initial quiz grades. Due to the similarity of this factor to FSG (the average of the test grades for Blocks II through VII), the researchers examined whether FSG could sufficiently represent this dimension. FSG correlates highest (.80) with Factor 2, followed closely by FSG2 (.79). The unit-weighted test-plus-quiz sum and Factor 2 correlate .82 (not shown in Table 134). While the correlation between the unit-weighted test-plus-quiz sum and Factor 2 slightly exceeds that for FSG and Factor 2, the school already uses FSG and FSG represents a useful summary measure. The sum of the quizzes correlates .89 with Factor 2 and .59 with FSG (not shown in Table 134). Thus, the quizzes compose some aspect of Factor 2, independent of the test grades, but their scale of measurement differs from that of the test (and block) grades.

WPM (the average of Block I By-Pass Typing Test, Final Typing Test, and AFPT70 Typing Test) correlates .98 with Factor 3 using either raw or standard scores. Therefore, the average of the typing test scores represents a meaningful criterion dimension.

These composites have the advantage of not overlapping with any other composite; variables on any one composite do not appear on any other composite. This approach creates conceptually independent dimensions.

Recommendations. In addition to FSG, use the sum of student training hours for Blocks II through VII and the mean of typing tests (WPM).

SUMMARY AND DISCUSSION

Table 135 summarizes the recommended criterion measures in addition to FSG for the 27 curricula investigated. For 8, we recommend only a single overall criterion (i.e., either FSG or some final average). For 9, we recommend 2 criteria. For 9 schools, we recommend 3 criteria; and for 1 school, we recommend 4 criteria.

Notice that the training for seven different specialties had more than one curriculum ongoing during data collection for this project. For Navy ET, these represent two separate courses: (a) Electronics Technician, Phase I, ET(I), and (b) Electronics Technician, Phase II, ET(II). For Army 11H (Heavy Antiarmor Weapons Crewman), the two curricula represent ongoing parallel curricula with a common initial component. For Army 19K (Tank Crewman), the four curricula basically represent instructor freedom to reorder training content and tests. In addition to the changes in the 19K school, four other schools (i.e., a total of 5) implemented changes to the curricula during data collection.

Investigations of Curriculum Changes

During the course of this study, 5 of the 18 schools (or 27.8%) did change their curricula. For 19K, differences amounted to instructor freedom to order curricula and tests. For AV, the school kept the same content areas but changed its instruction in 1 the of 6 areas. The AV school also changed lab scoring to pass/fail. For MM, the school integrated the curriculum from the feeder school (PE) with their curriculum and began using their own military instructors instead of civilians. For OS, the school reordered parts of the curriculum and ceased its practice of including quiz scores in the FSG. For 27230, the school moved

APPENDIX B

STUDENT ACTION CODES

Student Action Codes

Appendix B lists and defines student action codes for the three services in the study. Student action codes indicate the reasons a school dropped a student from training.

Table B-1

Student Action Codes (Navy)

CODE	DEFINITION	ACTION[a]
A__	ACADEMIC SETBACK PREFIX	
ATU	Possible typographical error (AMS school)	N
F__	ACADEMIC ATTRITION PREFIX	
FAC	Lack of reading skills	R
FAF	Lack of math skills	R
FAG	Lack of comprehension/retention of material	R/T
FAJ	Lack of comprehension/retention of material	R
FAM	Lack of language proficiency	R
FCD	Lack of manual skills/dexterity in use of tools	R/T
FCG	Lack of knowledge application	R/T
FCJ	Lack of knowledge application	R
G__	NON-ACADEMIC ATTRITION PREFIX	
GA_	MOTIVATIONAL ATTRITION	
GAA	Disinterest/Negative military attitude	R/T
GAD	Disinterest/Dropped at student's request	R/T
GAG	Lack of performance/Not school of choice	R/T
GAJ	Lack of performance/Not school of choice	R
GAM	Lack of performance/Not what expected	R
GAN	Lack of performance/Negative training attitude	R/T
GAQ	Lack of performance/Negative training attitude	R
GB_	ADMINISTRATIVE ATTRITION	
GBA	Alcohol rehabilitation	R/T
GBB	Alcohol rehabilitation	D/S
GBG	Hardship	R/T
GBH	Hardship	D/S
GBJ	Hardship	R

[a]Note: Action indicates the student's future status after attrition.

R/T	Reassigned/Transferred
D/S	Discharged/Separated
R	Reclassified
N	Not Defined

Table B-1 (cont'd)

CODE	DEFINITION	ACTION[a]
GC_ THRU GG_	MEDICAL ATTRITION	
GCB	Pregnancy	D/S
GCE	Orthopedic/Service connected	D/S
GCG	Orthopedic/Pre-Service	R/T
GCH	Orthopedic/Pre-Service	D/S
GCL	Podiatry/Service connected	D/S
GDS	Neurology/Service connected	D/S
GDY	Dermatology/Pre-Service	D/S
GEB	Internal Medicine/Service connected	D/S
GEC	Internal Medicine/Service connected	R
GEE	Internal Medicine/Pre-Service	D/S
GEL	Ear, Nose, Throat/Pre-Service	D/S
GEM	Ear, Nose, Throat/Pre-Service	R
GEV	Psychiatric/Service connected	D/S
GEY	Psychiatric/Pre-Service	D/S
GFB	Psychiatric (Suicidal)/Service connected	D/S
GFE	Psychiatric (Suicidal)/Pre-Service	D/S
GFH	Psychological (Personality Disorders)	D/S
GFL	Psychological (Enuresis)	D/S
GFP	Psychological (Sleepwalking)	D/S
GFQ	Psychological (Sleepwalking)	R
GFR	Psychological (Situation reaction)	R/T
GGA	Other medical/Service connected	R/T
GGB	Other medical/Service connected	D/S
GGC	Other medical/Service connected	R
GGD	Other medical/Pre-Service	R/T
GGE	Other medical/Pre-Service	D/S
	OTHER NON ACADEMIC ATTRITION	
GHA	Legal (Arrest by civil authorities)	R/T
GHE	Legal (Civil conviction)	D/S
GHN	Legal (Misconduct)	R/T
GHP	Legal (Misconduct)	D/S
GHR	Legal (Substance abuse)	R/T
GHS	Legal (Substance abuse)	D/S
GHV	Homosexuality	D/S

[a]Note: Action indicates the student's future status after attrition.

R/T	Reassigned/Transferred
D/S	Discharged/Separated
R	Reclassified
N	Not defined

Table B-1 (cont'd)

CODE	DEFINITION	ACTION[a]
GJB	Death/Non-Training related	D/S
GKL	Obesity	D/S
GLH	Fraudulent Enlistment (Drug subsequence)	D/S
GLS	Fraudulent Enlistment (Arrest pre-service)	D/S
GMB	Erroneous Enlistment	D/S
GNE	Other Non-Academic	D/S
GUR	Legal (Declared deserter)	D/S
H__	ADMINISTRATIVE DISENROLLMENT PREFIX	
HAC	Cancellation of class/course	R
HBC	Rating or program conversion	R
HCA	Change in student's orders	R/T
HCB	Change in student's orders	D/S
HCC	Change in student's orders	R
HDA	Failure to meet prerequisites	R/T
H^C	Failure to meet prerequisites	R
HDD	Possible typographical error (EN and ET schools)	
HDJ	Possible typographical error (ET school)	
HEA	Failure to meet security requirements	R/T
HEB	Failure to meet security requirements	D/S
HEC	Failure to meet security requirements	R
ZXX	Administrative drop/Restart at a later date	
ZRD	Completed training	

[a]Note: Action indicates the student's future status after attrition.

R/T	Reassigned/Transferred
D/S	Discharged/Separated
R	Reclassified
N	Not Defined

Table B-2

Student Action Codes (Air Force)

Air Traffic Controller (27230)		Personnel Specialist (73230)	
CODE[a]	DEFINITION	CODE[a]	DEFINITION
LA	Academic Deficiency	I	Incomplete
LG	Separated Service	U	Unsuccessful
LI	Misconduct		
LJ	Entry into the Military Academy		
LL	Death - Training Related		
LM	Medical		
LP	Prerequisite Deficiency		
LQ	Death - Other		
LR	Performance Deficiency		
LS	Security		
LT	Administrative Reasons		
LU	Unsuitability		
LV	Compassionate		
LW	Excessive Absence (including AWOL)		
LX	Other		

[a]Air Force codes result in the student's immediate elimination from training.

Table B-3

Student Action Codes (Army)

CODE[a]	DEFINITION
1	Medical Reasons
2	Failed to Qualify
3	Discharged
4	Unknown

[a]Army codes result in the student's immediate elimination from training.

APPENDIX C

AVIATION ELECTRICIAN'S MATE (AE) TEST WEIGHTS

Aviation Electrician's Mate (AE) Test Weights

Table C - 1

Aviation Electrician's Mate (AE) Test Weights

Test	Weight
Knowledge Progress Test (module #301)	100% = Unit 0 Grade
Knowledge Progress Test (module #311)	100% = Unit 1 Grade
Performance Progress Test (module #322) Knowledge Progress Test (module #321)	30% 70% = Unit 2 Grade
Performance Progress Test (module #332) Knowledge Progress Test (module #331)	30% 70% = Unit 3 Grade
Performance Progress Test (module #342) Within-course Comprehensive Test I (module #341)	30% 70% = Unit 4 Grade
Performance Progress Test (module #352) Knowledge Progress Test (module #351)	30% 70% = Unit 5 Grade
Knowledge Progress Test (module #361)	100% = Unit 6 Grade
Performance Progress Test (module #372) Knowledge Progress Test (module #371)	40% 60% = Unit 7 Grade
Performance Progress Test (module #382) Knowledge Progress Test (module #381)	40% 60% = Unit 8 Grade

Table C - 1 (cont'd)

Test	Weight
Performance Progress Test (module #392)	10%
Performance Progress Test (module #393)	10%
Performance Progress Test (module #394)	10%
Performance Progress Test (module #395)	10%
Performance Progress Test (module #396)	10%
Within-course Comprehensive Test II (module #391)	50%
	= Unit 9 Grade
Performance Progress Test (module #402)	10%
Performance Progress Test (module #403)	10%
Performance Progress Test (module #404)	5%
Knowledge Progress Test (module #401)	75%
	= Unit 10 Grade
Performance Progress Test (module #412)	40%
Knowledge Progress Test (module #411)	60%
	= Unit 11 Grade
Performance Progress Test (module #422)	30%
Knowledge Progress Test (module #421)	70%
	= Unit 12 Grade
Performance Progress Test (module #432)	5%
Performance Progress Test (module #433)	10%
Performance Progress Test (module #434)	10%
Performance Progress Test (module #435)	5%
Performance Progress Test (module #436)	10%
Knowledge Progress Test (module #431)	60%
	= Unit 13 Grade
Performance Progress Test (module #442)	50%
Within-course Comprehensive Test III (module #441)	50%
	= Unit 14 Grade
Knowledge Progress Test (module #451)	100%
	= Unit 15 Grade

Table C - 2

Aviation Electrician's Mate (AE) Unit Weights

Unit	Weight
Unit 0 Grade	3%
Unit 1 Grade	5%
Unit 2 Grade	6%
Unit 3 Grade	6%
Unit 4 Grade	8%
Unit 5 Grade	7%
Unit 6 Grade	5%
Unit 7 Grade	5%
Unit 8 Grade	7%
Unit 9 Grade	10%
Unit 10 Grade	6%
Unit 11 Grade	8%
Unit 12 Grade	7%
Unit 13 Grade	5%
Unit 14 Grade	10%
Unit 15 Grade	2%
	= Final School Grade

APPENDIX D

AVIATION ORDNANCEMAN (AO) TEST WEIGHTS

Table D - 1

Aviation Ordnanceman (AO) Test Weights

Test	Weight
Curriculum A:	
Mean of all Practical Works	20%
Mean of all Knowledge Progress Tests	80%
	= N
N	90%
Final Comprehensive Knowledge Test	10%
	= Final School Grade
Curriculum B:	
Mean of all Practical Works	10%
Mean of all Knowledge Progress Tests	90%
	= N
N	70%
Within-course Comprehensive Knowledge Test	10%
Within-course Comprehensive Performance Test	10%
Final Comprehensive Knowledge Test	10%
	= Final School Grade

APPENDIX E

AVIATION TECHNICIAN (AV) CHANGES AND TEST WEIGHTS

Aviation Technician (AV) Changes and Test Weights

Before June 28, 1991 (Julian: 91178), the school weighted the course lab scores and included these scores in the FSG. On this date, the school changed its scoring method for labs to satisfactory/unsatisfactory and no longer included lab scores in the FSG. Because of these changes, the school revised its test weighting scheme. Below, we provide both weighting systems (before and after the changes of June 28, 1991). In both tables, the school provided RGI with the school assigned weights and we calculated the contribution of each test to the FSG.

Table E-1 applies to students enrolled before Julian date 91178. The AV school altered its curriculum three times while using this weighting system. The school added Test 700 to Part 6, then added Test 445 to Part 4, then removed Test 500 from Part 5. The present AV instructors did not work at the AV school at the time of these changes. Consequently, the school did not know how the previous instructors redistributed the test weights to adjust for the changes. Furthermore, the AV school records do not indicate the effect of these changes upon the test weights. Without this information, we developed assumptions for these weights, based upon earlier and later trends in the school's methods of weight distribution. Then, we randomly selected several ISS cases and used a hand calculator to confirm the assumed weights. In Table E-1, we marked each assumed weight with an asterisk.

Table E-2 provides the revised weighting system the AV school used for all students enrolled as of Julian data 91178. The table includes course #60 test module numbers in parentheses because the school continued to use the revised weighting scheme after changing the course number to 60 in December, 1991.

Table E - 1

Aviation Technician (AV) Test Weights (For studends enrolled before June 28, 1991)

Test or Lab Number	School Assigned Weight	Contribution to FSG
PART 1:		
Knowledge Test 111	100% = Section 1 Grade	2.0280%
Knowledge Tests 121 & 122	44.4% (22.2% each)	1.9971% each
Mean Score of Labs 109, 119, 129, 139	11.1%	.9986%
Performance Test 124	44.5% = Section 2 Grade	4.0032%
Knowledge Tests 131 & 132	44.4% (22.2% each)	1.9971% each
Mean Score of Labs 149, 159, 169, 179 (If registered after Julian date 91157, this average includes Lab 189)	11.1%	.9986%
Performance Test 133	44.5% = Section 3 Grade	4.0030%
Section 1 Grade	07.8%	
Section 2 & 3 Grades	69.2% (34.6% each)	
Comprehensive Tests 123 & 100	23.0% (11.5% each) = PART 1 GRADE	2.9900% each
PART 2:		
Knowledge Tests 211, 221, 241	85.8% (28.6% each)	2.0002% each
Mean Score of Labs 219, 229, 239, 249	14.2% = Section 1-4 Grade	.9940%
Knowledge Tests 251, 252, & 254	39.9% (13.3% ea.)	1.9950% each
Mean Score of Labs 259, 269, 279, 289, 299, 209	06.7%	1.0005%
Performance Tests 253 & 255	53.4% (26.7% ea.) = Section 5 Grade	4.0050% each
Section 1-4 Grade	28.0%	
Section 5 Grade	60.0%	
Comprehensive Test 200	12.0% = PART 2 GRADE	3.0000%
PART 3:		
Knowledge Tests 321, 331, & 341	85.8% (28.6% ea.)	2.0020% each
Mean Score of Labs 309, 319, 329, 339, 349, 369	14.2% = PART 3 GRADE	.9940%

Table E - 1 (cont'd)

Test or Lab Number	School Assigned Weight	Contribution to FSG
PART 4:		
If enrolled before 91105 and not in class number 90820, 90821, 91010, 91011, 91140, 91141, 91280, or 91281:		
Knowledge Tests 431, 441, 442, & 443	61.6% (15.4% each)	2.0008% each
OR		
If enrolled after 91104 or in class number 90820, 90821, 91010, 91011, 91140, 91141, 91280, or 91281:		
Knowledge Tests 431, 441, 442, 443, & 445	61.6%* (12.32* each)	1.6006% each
Mean Score of Labs 409, 419, 429, 439, 449, 459	07.7%	1.0004%
Performance Test 444	30.7%	3.9885%
	= Section 1-4 Grade	
Sec ion 1-4 Grade	81.2%	
Comprehensive Test 400	18.8%	3.0008%
	= PART 4 GRADE	
PART 5:		
If enrolled before 90183:		
Knowledge Tests 511 & 521	30.8% (15.4% each)	2.0008% each
Mean Score of Labs 509, 519, 529, 539	07.8%	1.0134%
Performance Tests 512 & 522	61.4% (30.7% each)	3.9885% each
	= Section 1-3 Grade	
Sections 1-3 Grade	81.2%	
Comprehensive Test 500	18.8%*	3.0080%
	= PART 5 GRADE	
OR		
If enrolled after 90182:		
Knowledge Tests 511 & 521	43.8%* (21.9%* each)	3.5040% each
Mean Score of Labs 509, 519, 529, 539	06.2%	.9920%
Performance Tests 512 & 522	50.0% (25.0% each)	4.0000% each
	= PART 5 GRADE	
PART 6:		
Knowledge Test 601	20.0%	2.0000%
Knowledge Tests 600 & 700	30.0%* (15.0%* each)	3.0000% each
Mean Score of Labs 609 & 619	10.0%	1.0000%
Performance Test 611	40.0%	4.0000%
	= PART 6 GRADE	

For the weighting scheme above, the contribution of parts 1-6 to the FSG is as follows.

PART 1	26%
PART 2	25%
PART 3	07%
PART 4	16%
PART 5	16%
PART 6	10%

Table E - 2

Aviation Technician (AV) Test Weights (For students enrolled since June 28, 1991)

Test Number	School Assigned Weight	Contribution to FSG
PART 1:		
Knowledge Tests 111 (100), 121 (106), 122 (115), 131 (139), 132 (148)	11.10 (2.22 each)	.5772% each
Performance Tests 124 (127) & 133 (160)	08.46 (4.23 each)	1.0998% each
Comprehensive Tests 123 (130) & 100 (163)	06.44 (3.22 each)	.8372% each
	= 26.0	
PART 2:		
Knowledge Tests 211 (206), 221 (212), 241 (221), 251 (227), 252 (252), 254 (269)	13.32 (2.22 each)	.5550% each
Performance Tests 253 (251) & 255 (275)	08.46 (4.23 each)	1.0575% each
Comprehensive Test 200 (281)	03.22	.8050%
	= 25.00	
PART 3:		
Knowledge Test 321 (306)	02.22	.1551%
Knowledge Test 331 (315)	02.33	.1629%
Knowledge Test 341 (324)	02.44	.1706%
	= 06.99	
PART 4:		
Knowledge Tests 431 (412), 441 (424), 442 (433), 443 (439), 445 (448)	08.65 (1.73 each)	.2770% each
Performance Test 444 (451)	04.18	.6692%
Comprehensive Test 400 (454)	03.18	.5091%
	= 16.01	
PART 5:		
Knowledge Tests 511 (521) & 521 (545)	07.50 (3.75 each)	.6000% each
Performance Tests 512 (518) & 522 (539)	08.50 (4.25 each)	.6800% each
	= 16.00	
PART 6:		
Knowledge Test 601 (600)	02.25	.2250%
Knowledge Tests 600 (605) & 700 (606)	03.50 (1.75 each)	.1750% each
Performance Test 611 (604)	04.25	.4250%
	= 10.00	

For this weighting scheme, the contribution of parts 1-6 to the FSG is as follows.

PART 1	26.00%
PART 2	25.00%
PART 3	06.99%
PART 4	16.01%
PART 5	16.00%
PART 6	10.00%

APPENDIX F

ELECTRONICS TECHNICIAN (ET) PHASE 1 TEST WEIGHTS

Electronics Technician (ET) Phase 1 Test Weights

Table F - 1

Electronics Technician (ET) Phase 1 Test Weights

Test	Weight
Knowledge Test (Area 100)	5%
Performance Test (Area 200)	1%
Knowledge Test (Area 200)	9%
Performance Test (Area 300)	2%
Knowledge Test (Area 300)	8%
Performance Test (Area 400)	2%
Knowledge Test (Area 400)	8%
Performance Test (Area 500)	2%
Knowledge Test (Area 500)	8%
Performance Test (Area 600)	2%
Knowledge Test (Area 600)	8%
Performance Test (Area 700)	3%
Knowledge Test (Area 700)	12%
Performance Test (Area 800)	3%
Knowledge Test (Area 800)	12%
Performance Test #1 (Area 900)	2.25%
Performance Test #2 (Area 900)	2.25%
Knowledge Exam (Area 900)	10.5%
	= Final School Grade

APPENDIX G

MACHINIST'S MATE (MM2) CHANGES AND TEST WEIGHTS

Table G - 2

Machinist's Mate (MM2) Test Weights

Test or Quiz	Weight
Knowledge Test 1 (module #305)	90%
Quiz 1 (module #204)	10%
	= Unit 1 Grade
Knowledge Test 2 (module #309)	90%
Quiz 2 (module #206)	05%
Quiz 3 (module #208)	05%
	= Unit 2 Grade
Knowledge Test 3 (module #313)	90%
Quiz 4 (module #212)	10%
	= Unit 3 Grade
Knowledge Test 4 (module #317)	90%
Quiz 5 (module #214)	10%
	= Unit 4 Grade
Average of Unit Grades 1-4	80%
Comprehensive Test 1 (module #319)	20%
	= Phase 1 Grade
Knowledge Test 5 (module #325)	90%
Quiz 6 (module #223)	05%
Quiz 7 (module #224)	05%
	= Unit 5 Grade
Knowledge Test 6 (module #328)	90%
Quiz 8 (module #227)	10%
	= Unit 6 Grade
Knowledge Test 7 (module #331)	90%
Quiz 9 (module #230)	10%
	= Unit 7 Grade

Table G - 2 (Cont'd)

Test or Quiz	Weight
Knowledge Test 8 (module #334)	100%
	= Unit 8 Grade
Knowledge Test 9 (module #338)	90%
Quiz 10 (module #235)	05%
Quiz 11 (module #237)	05%
	= Unit 9 Grade
Knowledge Test 10 (module #341)	90%
Quiz 12 (module #239)	10%
	= Unit 10 Grade
Knowledge Test 11 (module #344)	90%
Quiz 13 (module #242)	10%
	= Unit 11 Grade
Average of Unit Grades 5-11	75%
Comprehensive Test 2 (module #349)	20%
Performance Test (module #144)	05%
	= Phase 2 Grade
Phase 1 Grade	50%
Phase 2 Grade	50%
	= Final School Grade (FSG)