



## The Development of a test for use in selecting Naval Postgraduate School students

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THE DEVELOPMENT OF A TEST FOR USE IN  
SELECTING NAVAL POSTGRADUATE SCHOOL STUDENTS

William G. Mollenkopf

Final Report to the Superintendent  
of the U. S. Naval Postgraduate School

EDUCATIONAL TESTING SERVICE

Princeton, N. J.

June 1951

RESEARCH

REPORT

THE DEVELOPMENT OF A TEST FOR USE IN  
SELECTING NAVAL POSTGRADUATE SCHOOL STUDENTS

A B S T R A C T

During a three-year period the Educational Testing Service has carried on a research program for the U. S. Naval Postgraduate School for the purpose of developing a test to be used as part of the means of selecting students for the School. Three experimental test batteries have been developed during this period and tried out at the School. In addition, a five-part aptitude test was administered in 1948 "in the fleet" to applicants for admission to the School.

All tests have been evaluated against criteria of academic success at the School. In addition, 1948 tests have been judged for effectiveness in predicting continuation at the School.

Accumulated validation data led to the recommended test, which consists of Mathematics Aptitude, Advanced Mathematics, Physical Science and Engineering, Interpretation of Scientific Data, and Experimental Science sections.

The recommended test can confidently be expected to be of significant value in determining which of the applicants are most likely to succeed in their work at the Postgraduate School.

## Foreword

This report is a summary of the three-year research program carried out by the staff of the Educational Testing Service, with William G. Mollenkopf as principal investigator, for the purpose of developing a test the scores from which would be used in the process of selecting students for admission to the U. S. Naval Postgraduate School.

Special acknowledgements are due to Rear Admirals H. A. Spanagel and E. E. Herrmann, respectively former and present Superintendents of the U. S. Naval Postgraduate School, for the support given to the program and the interest shown in its progress. Much helpful assistance has been given by Captains J. M. P. Wright, former Assistant Superintendent; H. T. Walsh, present Assistant Superintendent; and R. D. Harwood, Administrative Officer; and also by Drs. Ford L. Wilkinson, Jr., former Academic Dean; and Roy S. Glasgow, present Academic Dean. Thanks are also expressed for the help of the late Dr. E. G. Brundage of the Bureau of Naval Personnel and of Dr. John T. Wilson of the Office of Naval Research.

THE DEVELOPMENT OF A TEST FOR USE IN  
SELECTING NAVAL POSTGRADUATE SCHOOL STUDENTS

Introduction

In May of 1948 the Educational Testing Service undertook a research program for the purpose of developing measures that could be used as part of the means of selecting officers to be students at the U. S. Naval Postgraduate School. It was planned to devote three years of effort to the project, with experimental test batteries to be given to each of three successive groups of officers upon entrance into the School.

This research program has been carried out under the following contracts with the Navy Department: N-161 s-20233 for May-June, 1948; NO p 429 for July 1, 1948 to June 30, 1949; NO p 440 for July 1, 1949 to June 30, 1950; N9 onr-98202 for February 15, 1950 to February 14, 1951; and NO p 515 and NO p 516 for July 1, 1950 to June 30, 1951.

Outline of the Research Program

The first experimental battery. The first few months of the program were devoted to the assembly of an experimental test battery to be given to the group of officers entering the Postgraduate School in the summer of 1948. Because this was a first attempt at determining what tests would be effective in the Postgraduate School situation, this battery included not only measures of mathematical ability, physics, reading comprehension, and engineering -- measures which seemed to have excellent likelihood of being good predictors in view of their effectiveness in

other seemingly similar situations -- but also measures of ability in a number of other areas including spatial visualization, verbal reasoning, nonverbal reasoning, and word fluency. While several of these tests were especially prepared for this experimental administration, perforce many of the tests were drawn from those already available at ETS. There were 20 tests in all. A list of the tests with a brief description of each is given in Appendix A.

For judging the effectiveness of these tests it was decided to use as a criterion the quality-point ratios earned by the students. In the first study of test validities, completed in 1949, correlations between test scores and quality-point ratios for the first two terms of graduate work at the School were obtained. Tests found to be most predictive were the Engineering Achievement Test in Mathematics, the College Board Physics Test, the Graduate Record Examination in Engineering, a Reading Comprehension Test constructed for use at the School, a Mathematics Aptitude Test taken from the College Board Scholastic Aptitude Test, and a College Board Intermediate Mathematics Test. (The report to the Superintendent dated April 1949 gives the details of this study.)\*

Later in 1949 a study was carried out to determine the validities of the 1948 tests for predicting grade-point ratios for the entire first year of academic work at the School. The results were in excellent agreement with those described above. In this second validity study the effectiveness of each test was evaluated not only by means of a product-

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\*A list of the reports which have been submitted, giving date and title, is provided in Appendix B.

moment correlation but also by means of a bar chart. These charts have also been employed in all succeeding validity studies and depict for each of several parts of the score range on a particular test what percent of the student officers having such scores attained quality-point ratios of 2.0 or better. (Cf. report of November 1949.)

Validation of the 1948 tests against second-year grade-point averages was carried out under an Office of Naval Research contract. Validities of the tests for predicting second-year quality-point ratios were found to be consistently and appreciably lower than those for the first year. Part of these decreases were ascribed to an observed lower reliability in the second-year grades as compared with those of the first year, and part to selective drop-out, with the remainder due to differences between the curricula and to real changes in the students themselves, as in motivation. (Cf. O.N.R. Technical Report, August 1950.)

Recently the validities of the tests in the first experimental battery were obtained against the criteria of quality-point ratios for the full second year and also for half of the third year of work at the School. Validities for the third year tended to be somewhat higher than those for the second year. Tests that were effective for predicting success in the first year were found generally to be effective also for the second and third years. This study also investigated how well the 1948 tests predicted the criterion of continuation in school. Substantial agreement was observed between the product-moment correlations against the quality-point ratio criterion and the biserial coefficients computed against the continue-drop-out criterion except in the case of

the Reading Comprehension Test, which failed to correlate significantly with the latter criterion. (Cf. report of June 1951.)

A summary of the validity data for the 1948 tests is given in Table 1 at the end of this report.

Comparison of admitted and non-admitted groups. From the very beginning of this research program it was realized that adequate information regarding characteristics of the applicant group could not be gained through testing only those individuals who had already been admitted to the Postgraduate School, since the officers entering the School each year constitute a selected group taken from considerably larger number of candidates. Of particular concern was the fact that validity coefficients of tests might be markedly lowered in the event of any great reduction in the range of talent through selection.

Arrangements were therefore made with the Bureau of Naval Personnel to have a special experimental test sent out to the commanding officers of persons applying for admission to the School, for administration to the applicants. The test, called the Postgraduate School Aptitude Test, Form WNPF, consisted of five parts: Reading Comprehension, Mathematics Aptitude, Verbal Antonyms, Spatial Intersections, and Elementary Physics. (See Appendix A for a more detailed description.) Administration was carried out late in the fall of 1948.

For four of the five parts of Form WNPF the mean score for the Admitted Group was significantly higher than that for the Non-Admitted Group. Only for the Verbal Antonyms part was the difference in mean scores

nonsignificant. When the variabilities of scores made by the two groups on the various sections were compared, it was found that the greatest amount of reduction in range of talent from applicant to selected group had occurred for the Mathematics Aptitude part. Lesser effects were noted for the Reading Comprehension, Spatial Intersections, and Physics parts, while no reduction in range of talent was observed for the Verbal Antonyms part.

These results were of importance in considering the validation data already obtained and to be obtained. It was clear that the observed low validity of Verbal Antonyms could not be ascribed to severe restriction of range on this variable, and that observed validities for mathematics tests were likely to have been lowered more by the present process of selection than those of other tests involved in the study. (Cf. report of August 1950.)

The second experimental battery. The composition of the second experimental test battery, to be administered to the group entering the Postgraduate School in July 1949, was influenced by the fact that members of this group would already have taken the Postgraduate School Aptitude Test WNPF mentioned above in connection with the study of admitted and non-admitted groups. Seven tests were developed for the second battery, some, like the Advanced Mathematics, Engineering, Physics, and Mechanics tests, being outgrowths of measures tried in 1948, whereas others represented attempts to get at different abilities which seemed to possess good likelihood of adding to the predictive effectiveness of the tests which already had been found useful. These latter were a Reading Speed

test, an Experimental Science test, and an Interpretation of Data test. Brief descriptions of the tests will be found in Appendix A.

Initial evidence on the validity both of the seven tests given in 1949 and of the five parts of the Naval Postgraduate School Aptitude Test WNPF was obtained using as a criterion quality-point ratios for the first two terms of academic work at the School. Of the seven tests comprising the 1949 battery, scores for all tests except the Reading Speed Test were found to be highly predictive of academic success at the School as judged both by use of bar charts showing what per cent of students in each of four score ranges on the test had quality-point ratios of 2.0 or better and also by product-moment coefficients of correlation between test scores and quality-point ratios. Of the five parts of Test WNPF, the Mathematics Aptitude Test was found to possess high discriminating ability. Scores on the Reading Comprehension and Elementary Physics parts were also significantly related to the criterion. Results for tests similar to those given in 1948 were in good agreement with those previously obtained. Of the distinctly new tests tried out, Experimental Science and Interpretation of Data were found to be quite promising, but Reading Speed was found ineffective.

Further evidence on the validity of these twelve measures (i.e., the seven given in 1949 and the five parts of Form WNPF) was later obtained by computing correlations against quality-point ratios for the entire first year and also for the first two terms of the second year of academic work. Results for the entire first year were in excellent agreement with those for the first two terms. In the case of the second-year

validities, the phenomenon of shrinkage in test validities from first to second year previously observed with the 1948 tests also was found with the 1949 tests, though for 1949 the shrinkage was not so great as for the earlier year. (Cf. report of June 1951.)

In Table 2 at the end of the report are presented the correlations between scores on the twelve tests and quality-point ratios both for the entire first year and for half of the second year.

The third experimental test battery. The main purpose of the third (and last) experimental battery was to provide a further check on the effectiveness of those measures given in 1948 and 1949 for which the early evidence was promising. Only a limited amount of time was devoted to the development and try-out of additional measures.

Nine aptitude and achievement tests were prepared under an Office of Naval Research contract. Two additional tests were provided by the Research Division of the Bureau of Naval Personnel so that these tests, widely used in the Navy (one was a physics test, the other a mathematics test), could be related to the ETS-developed tests and to academic success at the Postgraduate School. The eleven tests were administered at the School in August 1950. A brief description of the tests will be found in Appendix A.

The validities of these tests were judged by relationships (using both the bar-chart technique and product-moment correlations) with quality-point ratios for the first two terms at the School. Tests having validity coefficients of .40 or higher were Reading Comprehension,

Mathematics Aptitude, Advanced Mathematics, Experimental Science, Physical Science and Engineering, Interpretation of Scientific Data, and the two BuPers tests (General Mathematics NAVPERS and General Physics NAVPERS). The Consequences Test as scored by the techniques described in Appendix A proved to be ineffective, and the Induction of Relationships test was found to be much too easy for the Postgraduate School group. (Cf. report of June 1951.)

Study of the predictiveness of Naval Academy departmental standings.

The suggestion had been made that there be a study of the effectiveness with which standings in various departments at the Naval Academy would predict later academic success at the Naval Postgraduate School. Since about half of the Postgraduate School students are Annapolis graduates, it seemed valuable to investigate whether departmental standings at the Academy would effectively add to the prediction of success at the School that could be obtained by use of the selection tests. Hence a study of this problem was carried out in 1950-1951.

For each officer tested in 1948, 1949, or 1950 who was a Naval Academy graduate there were obtained from the appropriate Naval Academy Annual Register five class standings:

1. Completed course (all four years)
2. Ordnance and gunnery (last year)
3. Marine Engineering (last year)
4. Electrical Engineering (last year)
5. Mathematics (second year)

These standings were converted to a scale which for the entire class would have had a mean of 50 and a standard deviation of 10.

The converted standings were then correlated with scores on the experimental tests and with quality-point ratios for both the first and second years of work at the School. In all, five tables of correlation were computed, two for 1948 (first and second years), two for 1949 (first and second years), and one for 1950 (first year only). When the predictive effectiveness of combinations of the converted Naval Academy class standings and test scores was compared with the effectiveness of combinations of test scores alone for these five groups, it was found that in every case the effectiveness of prediction of Postgraduate School quality-point ratios was increased by using the class standings in combination with the test scores.

Since for four out of five of the analyses the standing in Marine Engineering was primarily responsible for the increase in predictive effectiveness, it was recommended that in the process of selecting students for the School the standing in Marine Engineering be given about the same weight as the score on the selection test. (Cf. report of June 1951.)

The recommended selection test. The evidence accumulated from the three experimental test batteries and from the administration of the five-part Aptitude Test WNPF indicated that the test to be recommended for use in selecting officers to be students at the Postgraduate School should contain the following parts: Mathematics Aptitude, Advanced Mathematics, Physical Science and Engineering, Interpretation of Scientific Data, and

Experimental Science. Consideration of the various multiple regression studies which had been carried out, and of the characteristics of the types of material, including time required per item and reliability, led to the decision to recommend the following as the selection test:

Part I		
	Section	Number of Items
	1. Interpretation of Scientific Data	20
	2. Advanced Mathematics	30
Part II		
	Section	Number of Items
	3. Experimental Science	20
	4. Physical Science and Engineering	25
	5. Mathematics Aptitude	25

It was recommended that each of the two parts be administered with an over-all time limit of 90 minutes, and that the time interval between parts not be fixed, but be not shorter than 30 minutes nor longer than 36 hours. The time limit is believed to be long enough for most applicants to attempt all of the items in the test. The division of the test into two parts, and the possibility of varying the time between parts, are intended to make the administration of the test fit into the many and varied circumstances under which it must be administered when applicants are tested at any shore installation or aboard any ship of the Navy Department.

Items for the recommended test were drawn only from those previously tried out at the Postgraduate School. Item-analyses and other statistical information were utilized in choosing the items for inclusion in the test.

Use of this recommended test as part of the means of selecting students for attendance at the Naval Postgraduate School may confidently be expected to improve the quality of the selection process.

TABLE 1

## VALIDITY COEFFICIENTS FOR TESTS GIVEN IN 1948

Test	Correlation with First-Year Quality-Point Ratios (Entire Year) N = 145	Correlation with Second-Year Quality-Point Ratios (Entire Year) N = 112	Correlation with Third-Year Quality-Point Ratios (1st Two Terms) N = 43	Biserial Correlation with Drop-out vs. Continue Criterion N = 145
1. Engineering Achievement Test in Mathematics	.76*	.33*	.42*	.67*
2. Physics Test, Form SA	.60*	.31*	.36	.62*
3. G.R.E. Advanced Test in Engineering (Form A)	.52*	.38*	.38	.38*
4. Verbal Antonyms, Form TA	.32*	.13	.15	.24
5. Reading Comprehension, Form WNPA	.44*	.19	.31	.19
6. Mathematics Test, WSA2, Subtest 4	.65*	.38*	.41*	.59*
7. Mathematics Test, WIM3, Subtest 6	.66*	.29*	.44*	.68*
8. Multiple Variates, VDPH2, II	.34*	.11	.26	.09
9. Picture Equations, VDPH4, III	.32*	.10	-.09	.33
10. Spatial Relations: Intersections, VACL, 10	.25*	.09	.17	.10
11. Spatial Relations: Identical Blocks, VACL, 10	.26*	.04	.11	.13
12. Mechanical Movements, WNPA	.34*	.24*	.44*	.26
13. Figure Classification, WNPA	.30*	.06	.20	.20
14. Figure Matrices, VDPH3, IV	.21*	.09	.43*	.07
15. Syllogisms, VDPH3, V	.29*	.05	.28	.14
16. Gottschaldt Figures, VDPH3, III	.07	-.03	-.03	.12
17. Productivity of Ideas, VDPH5, I	.16	.11	-.15	-.02
18. Related Words, WNPA	.22*	.12	.03	.28
19. Topics, WNPA	.18	.07	-.12	.15
20. Consequences, Score 1	.24*	.10	.01	.21
21. Consequences, Score 2	.01	-.12	-.34	-.03
22. Consequences, Score 3	.26*	.13	.02	.23
23. Consequences, Score 4	.26*	.11	.07	.28
24. Consequences, Score 5	.07	-.10	-.11	.14

\*A validity coefficient as great as this would occur by chance less than once in a hundred times when the true correlation was zero, for the N indicated at the head of the column.

TABLE 2  
 VALIDITIES OF TESTS GIVEN TO  
 GROUP ENTERING IN 1949

Test	Correlation with First- Year Grades N = 126	Correlation with Second- Year Grades N = 102
1. Physics XNPAL	.52*	.27*
2. Experimental Science XNPA2	.46*	.15
3. Mechanics XNPA3	.59*	.36*
4. Reading Speed XNPA4	.18	.14
5. Advanced Mathematics XNPA5	.57*	.44*
6. Interpretation of Data XNPA6	.48*	.17
7. Engineering XNPA7	.53*	.30*
8. Reading Comprehension WNPF1	.36*	.31*
9. Mathematics Aptitude WNPF2	.47*	.24
10. Verbal Antonyms WNPF3	.28*	.14
11. Spatial Intersections WNPF4	.45*	.19
12. Physics WNPF5	.44*	.21

\*A validity coefficient as great as this would occur by chance less than once in a hundred times when the true correlation was zero, for the N indicated at the head of the column.

TABLE 3  
 VALIDITIES OF TESTS GIVEN IN 1950  
 (N = 158)

Test	Correlation with Quality-Point Ratio for First Two Terms
1. Reading Comprehension WNPA	.40*
2. Mathematics Aptitude WNPA	.60*
3. Advanced Mathematics YNPA1	.65*
4. Induction of Relationships YNPA2	.29*
5. Experimental Science YNPA3	.47*
6. Physical Science and Engineering YNPA4	.56*
7. Interpretation of Scientific Data YNPA5	.56*
8. Spatial Visualization YNPA6	.34*
9. Consequences I	.09
10. Consequences II	-.01
11. General Mathematics NAVPERS	.63*
12. General Physics NAVPERS	.50*

\*A validity coefficient as great as this would occur by chance less than once in a hundred times when the true correlation was zero, for an N of 158.

## APPENDIX A

Descriptions of the 1948 Tests

1. Engineering Achievement Test in Mathematics, Form B. This test consisted of 60 questions in algebra, plane analytic geometry, trigonometry, differential calculus, and integral calculus. The time limit was two hours.
2. Physics Test, Form SA. This was a College Entrance Examination Board Achievement Test in Physics. It contained 60 questions on topics covered in the usual high-school course in physics. The time limit was 60 minutes.
3. Advanced Test in Engineering (Form A) of the Graduate Record Examination. This was a specialized test in engineering designed to be given to seniors in colleges of engineering or to first-year graduate students. There were 140 questions. The time limit was 105 minutes.
4. Verbal Antonyms, Subtest One of the College Entrance Examination Board Scholastic Aptitude Test, Form TA. The questions in this test required the student to indicate which two out of a group of four words were most nearly opposite in meaning. There were 80 questions. The time limit was 25 minutes.
5. Reading Comprehension, Form WNPA. This was a test especially prepared for use at USINPGS. The test consisted of six passages of scientific reading material each of which was followed by a set of questions to be answered on the basis of what was stated or implied in the passage. There were 30 questions in all, and the time limit was 30 minutes.

6. Mathematics Test, Subtest 4 of the College Entrance Examination Board Scholastic Aptitude Test Form WSA2 (Program 1). This was a mathematical aptitude test designed to minimize the effects on the score of length and recency of formal training in mathematics. The test contained 35 questions, and the time limit was 30 minutes.
7. Mathematics Test, Subtest 6 of the College Entrance Examination Board Intermediate Mathematics Test, Form WIM3. This was a high-school level test in mathematics, and contained 25 questions in arithmetic, plane geometry, and high-school algebra. The time limit was 30 minutes.
8. Multiple Variates, VDPH Book 2, Section II. This was a quantitative aptitude test consisting of 25 items in which the student was called upon to state for each of many small tables what algebraic relationship existed between the columns of numbers in these tables. The time limit was 25 minutes.
9. Picture Equations, VDPH Book 4, Section III. This was another quantitative aptitude test, consisting of items involving equations mostly presented in pictorial form. The student was given a table of the relations among the pictured elements and was called upon to indicate what quantity was needed for addition to one side of the equation so that it would balance. There were 20 problems and the time limit was 20 minutes.
10. Spatial Relations: Intersections, College Entrance Examination Board VAC1, Part I. Each item in this test showed a drawing of a solid figure cut by a plane. The student was called upon to select from

five figures presented him the one which correctly represented the shape on the cutting plane of the intersection between the solid figure and this plane. There were 60 items. The time limit was 30 minutes.

11. Spatial Relations: Identical Blocks, College Entrance Examination Board VACL, Part II. Each item in this test showed a solid block of some particular shape, to the right of which there were five other blocks. The student was asked to identify which one of these five was the same as the problem block, but seen from a different point of view. There were 30 items, and the time limit was 30 minutes.
12. Mechanical Movements, WNPA. The questions in this test were based upon numerous line drawings of mechanical devices involving cams, gears, pulleys, levers, and the like, and required the student to specify the direction, distance, or speed of motion of some part, or some function of these. There were 30 items, and the time limit was 30 minutes.
13. Figure Classification, WNPA. This was a nonverbal reasoning test. In each item there were presented two groups of figures, labelled A and B, followed by five numbered single figures. The problem was to decide what characteristic all A figures had which no B figure had, and then to determine which one of the five numbered figures possessed this characteristic. There were 25 items, and the time limit was 20 minutes.

14. Figure Matrices, VDPH Book 3, Section IV. This was another non-verbal reasoning test. Each item consisted of a square divided into nine smaller squares. A geometric figure was presented in the square in the upper-left corner, and this figure changed in a systematic and logical fashion in the squares to the right and downward. The problem was to determine what kind of figure should consequently appear in the lower-right corner, which was always left not filled in. There were 20 items, and the time limit was 20 minutes.
15. Syllogisms, VDPH Book 3, Section V. This was a test of verbal reasoning ability, in which each item presented several possible conclusions from which the one was to be selected which followed most logically from the stated premises. There were 20 items. The time limit was 15 minutes.
16. Gottschalldt Figures, VDPH Book 3, Section III. This was a test of perception and visualization in which the student was called upon to state which one of five simple figures was contained in a complex figure, all figures being straight-line geometrical ones. There were 15 items, and the time limit was 15 minutes.
17. Productivity of Ideas, VDPH Book 5, Section I, Part 2. The student was presented with a large number of lines each containing the statement, "It takes more than \_\_\_\_\_ to make a/an \_\_\_\_\_." He was told to fill these in as quickly as possible. The score was the number of statements completely filled in. The time limit was 7 minutes.
18. Related Words, WNPA. In this test the student was asked to think of a third word which was related in one way or another to each of two

given words. The first letter of the correct word was given, and the student wrote out the rest of the word. There were 90 items, and the time limit was 15 minutes.

19. Topics, WNPA. This was a test which sought to measure how many ideas a student might think of concerning a particular topic, such as, "a train journey." Each idea was to be listed separately, and the score was the number of ideas written down. The time limit was 5 minutes.

20. Consequences, WNPA. In this test six statements were presented, each beginning, "What would happen if ....." The student was asked to write down in a brief, concise way what would happen as a consequence of the condition specified, using a separate short sentence for each idea. Each situation was given a time of 5 minutes, and the over-all time limit was 30 minutes. Five scores were derived from the answers:

(1) Number of statements; (2) Number of these statements which were generalizations; (3) Number of these statements which were specific facts or concrete details; (4) Number of generalizations required to subsume all responses; and (5) Length of the longest run of consecutive, logically connected ideas.

#### Descriptions of the 1949 Tests

1. Physics XNPA1. This test consisted of 80 multiple-choice questions and problems in first-year college physics. (Since a separate test in mechanics was being given, this physics test did not contain items on mechanics.) The time limit was one hour.
2. Experimental Science XNPA2. In this test seven simple experiments were described in some detail. Each description was followed by a

set of ten statements pertaining to the experiment. A statement was to be classified under that one of the following categories which best described it:

- A. Agrees with the results of the experiment
- B. Contradicts the results of the experiment
- C. Not relevant to the experiment
- D. Justly criticizes the experiment
- E. Unjustly criticizes the experiment

There were 70 statements to be so classified. The time limit was one hour.

3. Mechanics XNPA3. This test contained 74 multiple-choice questions and problems in mechanics. The time limit was one hour.
4. Reading XNPA4. This was a speed of reading test introduced to supplement the reading comprehension measure also used on the same candidates. There were four seven-minute passages. Questions were interspersed in the passages read; the score was the number of these questions that were answered correctly.
5. Advanced Mathematics XNPA5. This test consisted of 60 multiple-choice items in college algebra, trigonometry, analytic geometry, differential calculus, and integral calculus. The time limit was two hours.
6. Interpretation of Data XNPA6. Items in this test required the test-taker to analyze data presented in the form of charts, tables, and graphs. There were 38 multiple-choice items in the test. The time limit was 70 minutes.

7. Engineering XINPA7. This test consisted of 62 multiple-choice items on engineering. The time limit was one hour.

Descriptions of the Subtests of the Naval  
Postgraduate School Aptitude Test, Form WNPF  
(One over-all time limit of three hours)

1. WNPF Part 1, Reading Comprehension. This test consisted of six passages of scientific reading material each of which was followed by a set of five questions to be answered on the basis of what was stated or implied in the passage. There were thus 30 questions in all in this part of the test.
2. WNPF Part 2, Mathematics Aptitude. This was a mathematical aptitude test consisting of 30 items chosen so as to minimize the effects on the score of length and recency of formal training in mathematics.
3. WNPF Part 3, Verbal Antonyms. This part contained 30 verbal antonyms items similar to those used in the verbal section of the College Board Scholastic Aptitude Test.
4. WNPF Part 4, Spatial Intersections. Each item in this test showed a drawing of a solid figure cut by a plane. The student was called upon to select from five figures presented him the one which correctly represented the shape on the cutting plane of the intersection between the solid figure and this plane. There were 50 items in the part.
5. WNPF Part 5, Elementary Physics. The items in this part were on topics covered in the usual high-school course in physics. There were 30 items in the part.

Descriptions of the 1950 Tests

1. Reading Comprehension WNPA. This test consisted of six passages of scientific reading material each of which was followed by a set of five questions to be answered on the basis of what was stated or implied in the passage. There were 30 questions and the time limit was 45 minutes.
2. Mathematics Aptitude WNPA. This was a mathematical aptitude test consisting of 30 items chosen so as to minimize the effects on the score of length and recency of formal training in mathematics. The score was the number right. The time limit was 50 minutes.
3. Advanced Mathematics YNPAL. This test consisted of 40 items in college algebra, trigonometry, analytic geometry, differential calculus, and integral calculus. (It was a revised form of the test given at the School in 1949.) The time limit was 80 minutes. There were two separately timed parts.
4. Induction of Relationships YNPA2. This was a radical revision of the Multiple Variates Test given in 1948. The student was called upon to state for each of many small tables what algebraic relationship existed between the columns of numbers in these tables. There were 42 items divided equally between two separately timed parts. The time limit was 60 minutes.
5. Experimental Science YNPA3. This was a revised form of the test given in 1949. In the test four simple experiments were described in some detail. Following each description was a set of ten statements per-

taining to the experiment. Each statement was to be classified under that one of the following categories which best described it:

- A. Agrees with the results of the experiment
- B. Contradicts the results of the experiment
- C. Not relevant to the experiment
- D. Justly criticizes the experiment
- E. Unjustly criticizes the experiment

There were 40 statements to be classified, and the time limit was 40 minutes. There were two separately timed parts.

6. Physical Science and Engineering YNPA4. Three types of item were included in this test: items in mechanics, items in physics, and items in engineering. These were drawn principally from the corresponding three tests given in 1949, and were grouped together because of the very high intercorrelations that were found for scores on these three tests. The test given in 1950 consisted of 60 items, and the time limit was 60 minutes. There were two separately timed parts.
7. Interpretation of Scientific Data YNPA5. Items in this test were all new. Strenuous efforts were made in constructing items to make success on them relatively uninfluenced by formal mathematical ability. There were 32 items in the test, requiring the students to analyze data presented in the form of charts, tables, and graphs. The time limit was 40 minutes. There were two separately timed parts.
8. Spatial Visualization YNPA6. In each item of this test the subject was called upon to imagine a square of paper folded and then punched with holes as indicated in the problem. He was called upon to select

from among five figures that one which showed the correct arrangement of these holes in the unfolded paper. There were 20 items in each of two separately timed parts. The time limit was 50 minutes.

9. General Mathematics, Form I, NAVPERS 16571. This test was supplied by the Research Division, Bureau of Naval Personnel. There were 45 questions. The time limit was 75 minutes.
10. General Physics Test, Form 2, NAVPERS 16572. This test was also supplied by the Research Division, Bureau of Naval Personnel. There were 70 questions. The time limit was 90 minutes.
11. Consequences. This was a revision and further development of a test tried out in 1948. Eight questions were presented each beginning, "What would happen if..." For the first four, the student was asked to write down as many consequences as he could think of, stating each in a brief, concise way. For the second set of four, the student was asked to state as many generalizations as seemed suitable for describing the consequences of the specified condition. Each question was given a separate time limit of five minutes. Two scores were derived, one for the first four items, the second for the last four items.

## APPENDIX B

REPORTS ON THE SELECTION-TEST RESEARCH PROGRAM  
CARRIED ON FOR THE POSTGRADUATE SCHOOL

<u>Date</u>	<u>Title</u>
1. October 1948	Preliminary Report on the Selection-Test Development Program of the U. S. Naval Postgraduate School (July 1948 Testing)
2. April 1949	Report on the Validation of Tests Against First- and Second-Term Grades and Quality-Point Ratios at the U. S. Naval Postgraduate School (July 1948 Testing)
3. November 1949	Validities of Tests Given in 1948 for Predicting First-Year Average Grades at the U. S. Naval Postgraduate School
4. May 1950	Validities of Tests Given in July 1949 and of Subtests of the Postgraduate School Aptitude Test Form WNPF for Predicting Average Grades for First Two Terms at the U. S. Naval Postgraduate School
5. August 1950	Prediction of Second-Year Grade-Point Averages at the U. S. Naval Postgraduate School (O.N.R. Technical Report)

<u>Date</u>	<u>Title</u>
6. August 1950	A Comparison of Admitted and Non-Admitted Groups at the U. S. Naval Postgraduate School
7. April 1951	Validities of Tests Given in 1950 for Predicting Average Grades for the First Two Terms at the U. S. Naval Postgraduate School
8. June 1951	Prediction of Second-Year and Third-Year Grade-Point Averages at the U. S. Naval Postgraduate School
9. June 1951	Effectiveness of Naval Academy Departmental Standings for Predicting Academic Success at the U. S. Naval Postgraduate School
10. June 1951	The Development of a Test for Use in Selecting Naval Postgraduate School Students (Final Report)