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ABSTRACT

The United States Training and Employment Service General Aptitude Test Battery (GATB), first published in 1947, has been included in a continuing program of research to validate the tests against success in many different occupations. The GATB consists of 12 tests which measure nine aptitudes: General Learning Ability; Verbal Aptitude; Numerical Aptitude; Spatial Aptitude; Form Perception; Clerical Perception; Motor Coordination; Finger Dexterity; and Manual Dexterity. The aptitude scores are standard scores with 100 as the average for the general working population, and a standard deviation of 20. Occupational norms are established in terms of minimum qualifying scores for each of the significant aptitude measures which, when combined, predict job performance. Cutting scores are set only for those aptitudes which aid in predicting the performance of the job duties of the experimental sample. The GATB norms described are appropriate only for jobs with content similar to that shown in the job description presented in this report. A description of the validation sample is also included. (AG)

TECHNICAL REPORT

ON

STANDARDIZATION OF THE GENERAL APTITUDE TEST BATTERY

FOR

MATHEMATICIAN (profess. & kin.) 020.028

S-213

U. S. Employment Service in
Cooperation with
Minnesota State Employment Service

February 1963

STANDARDIZATION OF THE GENERAL APTITUDE TEST BATTERY

FOR

MATHEMATICIAN (profess. & kin.) 020.088-018

S-213

Summary

The GATB, B-1002B, was administered to a final sample of 52 undergraduate students, juniors and seniors, majoring in the field of Mathematics at the College of Science, Literature and Arts, University of Minnesota, Minneapolis, Minnesota. The criterion consisted of the grade point averages. On the basis of mean scores, standard deviations, correlations with criterion, job analysis data, and their combined selective efficiency, Aptitudes G--Intelligence, N--Numerical Aptitude, and S--Spatial were selected for inclusion in the final test norms.

GATB Norms for Mathematician (profess. + kin.) 020.088

B-1001			B-1002		
Aptitude	Tests	Minimum Acceptable Aptitude Score	Aptitude	Tests	Minimum Acceptable Aptitude Score
G	CB-1-H CB-1-I CB-1-J	135	G	Part 3 Part 4 Part 6	130
N	CB-1-D CB-1-I	125	N	Part 2 Part 6	120
S	CB-1-F CB-1-H	125	S	Part 3	120

Effectiveness of Norms

The data in Table VI indicate that 9 of the 17 poor students, or 53 percent of them, did not achieve the minimum scores established as cutting scores on the recommended test norms. This shows that 53 percent of the poor students would not have been chosen if the recommended test norms had been used in the selection process. Moreover, 30 of the 38 students who made qualifying test scores, or 86 percent, were good students.

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TECHNICAL REPORT

I. Purpose

This study was conducted to determine the best combination of aptitudes and minimum scores to be used as norms on the General Aptitude Test Battery for the occupation of Mathematician (profess. + KIN.) 020.088

II. Sample

The General Aptitude Test Battery, B-1002B, was administered on March 31 and April 1, 1959 and on May 17 and 18, 1960 to a sample of 54 junior and senior undergraduate students majoring in mathematics, at the College of Science, Literature and Arts (SLA), University of Minnesota, Minneapolis, Minnesota. A list of all math majors who were either juniors or seniors was obtained from the Dean's office and letters were sent to the 104 students on this list. 54 of these students volunteered and participated in this study. Two of these students were dropped from the sample because of insufficient criterion data. The final sample consisted of 52 students, 43 male and 9 female. Most University of Minnesota SLA students take about 15 credits of work each quarter. The students in the final sample completed between 8 and 58 quarter credit hours in Mathematics courses, and between 42 and 220 quarter credit hours in all courses including Mathematics.

The sample of volunteers for this study were compared to a sample of non-volunteer University of Minnesota SLA mathematics majors with regard to overall grade point averages for all courses taken, and to performance on the ACE Psychological Examination. Since the data showed that the sample for this study scored significantly higher on the foregoing criteria, it cannot be assumed that this sample is a random sample of University of Minnesota SLA mathematics majors.

TABLE I

Mean (M), Standard Deviation (σ), Range, and Pearson Product-Moment Correlation with the Criterion (r) [Total Grade Point Average for All Courses Taken] for Age

N = 52	M	σ	Range	r
Age (years)	22.1	2.45	20-34	-.527**

The negative correlation of -.527, significant at the .01 level, between age and the criterion of total grade point average for all courses taken was most probably obtained because:

1. The higher ability students were able to take a heavier course load per quarter, achieve higher grades and thus complete their program at an earlier age.

2. Many more students received grades of F in the low group than in the high group. These students were required to repeat the same course or substitude an equivalent course, thus delaying commencement of their program.

3. Careful scrutiny of the data showed that 65 percent of the students in the low criterion group had transferred from the Institute of Technology, (whereas only 14 percent of the high criterion group had done so), with low scholastic standing to the "Arts" College, where they also achieved low scholastic records. These students were required to take additional course work to meet the requirements for graduation because many Institute of Technology courses transferred only as electives and did not meet the sequence or core requirements for S.L.A. Therefore these students had to spend more time in college to complete their program, and graduated at a later date.

4. Eleven of the thirty-five, or 31 percent of the students in the high criterion group had received credit for courses by taking special examinations. The number of quarter credits they received by taking special examinations ranged from 10 to 16. The course work from which most were exempt was freshman English (9 credits). None of the people in the low criterion group, or who were ranked in the bottom half of the sample, received credit for any course without actually taking the course work.

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III. Job Description

Job Title: Mathematician (profess. + kin.) 020.088

Job Summary: Conducts research in fundamental mathematics and in application of mathematical techniques to science, management, and other fields, and solves or directs solutions to problems in various fields by mathematical methods: Conducts research in such branches of mathematics as algebra, geometry, numbers theory, logic, and topology, and studies and tests hypotheses and alternate theories. Conceives and develops ideas for application of mathematics to wide variety of fields including science, engineering, military planning, electronic data processing, and management, and prepares reports summarizing recommendations. Applies mathematics or mathematical methods to solution of assigned problems in research, development, product logistics, and other functional areas, utilizing knowledge of such other fields as physics, engineering, astronomy, biology, economics, business and industrial management, or cryptography. Performs computations, applies methods of numerical analysis, and operates or directs operation of desk calculator and mechanical or electrical computation machines, analysers, and plotters in solving problems in support of mathematical, scientific, or industrial research activities. Acts as advisor or consultant to research personnel concerning mathematical methods and application. May be designated according to function as Mathematician, Research; Mathematician, Applied.

Course Summary: Learns to use and apply mathematical principles and theorums to solve mathematical problems in areas such as statistics, algebra, trigonometry, geometry and calculus.

Course Descriptions:

College Algebra - Systems of quadratic equations, ratio, proportion, variation, progressions, permutations, combinations, probability, binomial theorem, mathematical induction, inequalities, complex numbers, theory of equations, determinants, and applications.

Trigonometry - A course in analytic trigonometry emphasizing identities, equations, and properties of the functions; right and oblique triangles with logarithmic computation.

Analytic Geometry - Study of geometry by means of algebra. Topics included: Cartesian and polar coordinates, straight lines, circles, conic sections, loci of given equations, equations of given loci, solid analytic geometry.

Differential calculus - Includes: Derivatives and differentials of elementary functions; curve tracing; definitions of velocity, acceleration, curvature, etc; maxima and minima; related rates; mean value theorems; indeterminate forms; infinite series, expansions of functions.

Integral calculus - Includes: Formal integrations; geometrical and physical meaning of constants of integration; definite integrals; fundamental theorem of integral calculus; approximate integration; geometrical and physical applications; improper integrals; multiple integrals.

Intermediate calculus - Direction cosines, lines, planes; partial differentation and applications to curves, surfaces, directional derivatives, extrema, taylor series; moments, spherical coordinates; hyperbolic functions.

Synthetic Metric Geometry - Euclidean geometry including ruler and compass constructions and theorems on the triangle and circle not studied in a high school course in plane geometry.

Introduction to the Theory of Equations - Complex numbers, solution of algebraic equations, properties of polynomials; isolation of the real zeros of a real polynomial; determinants and linear equations.

Differential equations - Problem course, methods for solving ordinary differential equations of various types with the necessary theory for developing these methods.

Advanced calculus - Detail of some topics in calculus; partial differentiation; multiple integrals and change of variable; basic ideas and applications of vectors. Line and surface integrals; Stokes' and Green's theorems; exact differentials; Beta and Gamma functions.

Theory of numbers - Elementary properties of integers; prime and composite numbers; Euclid's algorithm; congruences; the theorems of Fermat and Wilson; primitive roots; indices; Galois imaginaries; finite algebras; Pythagorean and Heronian triangles; Diophantine equations.

IV. Experimental Battery

All the tests of the GATB, B-1002B, were administered to the sample group.

V. Criteria

The criteria (grades) for this study were recorded on grade transcripts and collected from the University of Minnesota during July of 1960. The grade transcripts included all courses completed by the end of the first summer session, July 19, 1960, at the University of Minnesota. Three types of criteria were analyzed to determine the final criterion to be used in validating the norms for this study. The first criterion consisted of total academic grade point average which was based upon all the course work taken while the student was registered in the College of Science, Literature and Arts with the exception of military drill, physical education and band which were excluded because of their nonacademic content. The second criterion consisted of the grade point average for mathematics courses only. The third criterion consisted of the grade point average for all the other course work taken while the student was registered in the "Arts" College excluding mathematics courses, military drill, physical education and band. The courses taken while the students were registered in other colleges were not included in any of the above criteria. Most students take about 15 credits of work each quarter.

The quality of work is indicated by grade points. Grade points are assigned to course grades as follows: To each credit with a grade of A, 4 grade points; to each credit with a grade of B, 3 grade points; to each credit with a grade of C, 2 grade points; to each credit with a grade of D, 1 grade point. An F carries no grade points. Thus for a 3 credit course completed with a grade of B a student would be assigned 9 grade points. Grade point averages were obtained by taking the number of grade points earned divided by the total number of credits earned (grades A to D) and failed. A grade point average of 2.0 (C average) is the minimum standard required for satisfactory progress toward the B.A. degree.

The Grade Point Average (GPA) for each criterion (total GPA, mathematics GPA, and other GPA) was calculated for all the students in the sample and arranged in rank order. The rank orders were converted to linear scores for purposes of computation of Pearson product-moment correlations between each criterion and the B-1002B Aptitudes. Thus each student had three GPA's which were indicative of the quality of work accomplished at the University of Minnesota. The Pearson product-moment correlations between each criterion (r_1 = total, r_2 = mathematics, and r_3 = other) and the B-1002B Aptitudes are shown in Table IV.

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The means (M), standard deviations (σ) and ranges of course credits for the three criteria are shown in Table II.

TABLE II

	M	σ	Range
Total course credits	128.1	46.8	42-220
Math course credits	36.4	14.9	8-58
Other course credits	91.7	35.7	28-172

The three criteria grade point average (GPA), means (M), standard deviations (σ), Ranges and Pearson product-moment correlations interrelating the criteria are shown in Table III. The GPA scores were not ranked or converted to linear scores in calculating the product-moment correlations interrelating the three criteria. A grade point average of 2.0 (C average) is the minimum standard required for satisfactory progress toward the B.A. degree.

TABLE III

	M	σ	Range	Total GPA	Other GPA
Total GPA	2.83	.57	1.72-3.91		.957**
Math GPA	2.86	.70	1.52-4.00	.834**	.656**
Other GPA	2.80	.58	1.66-3.91	.957**	

**Significant at the .01 level.

In view of the following considerations, it was decided that the total course GPA was to be used as the final criterion by which the norms in this study were validated. The reasons for the final choice of criterion are as follows:

1. It is representative of the work a math major must do in order to graduate from the University of Minnesota.

2. The degree of relationship between the mathematics GPA and the other GPA as evidenced by the Pearson product-moment correlation of .656 is sufficiently high to warrant combining the two criteria to form a final criteria. Thus the total GPA is probably more reliable than either the mathematics GPA or the other GPA used separately.

3. The criterion based on the total number of courses gives a sufficient range and permits us to obtain a sample of a large part of a student's academic behavior. It is probably more stable than would have been the case if we used only a small number of courses.

4. There are no significant correlations between the aptitudes as shown in Table IV for B-1002B Aptitudes and the mathematics GPA, which could be due to the restriction in number of courses or that the poorer student spends a disproportionate amount of time and energy on his math courses, thus sacrificing the other courses for the sake of obtaining higher grades in mathematics.

5. There were not any courses common to all students in the sample, making it impossible to construct a criterion based on a core of identical courses. Following are some factors which may have contributed to this finding: some of the math majors were exempt from college courses because they had passed a special test exempting them from certain courses (i.e., freshman English), and they had covered the material in high school (i.e., college algebra); many students had completed their college work in other colleges and these courses although similar were not identical in terms of title, content, texts, or instructors ratings to courses in the "Arts" College; and there were a large number of elective courses available in the mathematics curriculum.

VI. Qualitative and Quantitative Analyses

A. Qualitative Analysis:

The job analysis indicated that the following aptitudes measured by the GATB appear to be important for this occupation:

Intelligence (G) - Required to understand meanings and relationships of mathematical symbols, formulas, and concepts; to develop methods and procedures of problem solving through reasoning; and to present solutions in logical and systematic forms and sequences.

Verbal (V) - Required in understanding and expressing mathematical problems and concepts and their applications. This could involve translating numerical forms into words or vice versa.

Numerical (N) - Required to perform the arithmetic operations involving rapid and accurate solution of problems by using and developing formulas, equations, and other mathematical relationships.

Spatial (S) - Required to visualize and understand spatial relationships of objects and forces involved in mathematical problems and their resultant effects on each other.

On the basis of the job analysis data, the following aptitudes are considered obviously unimportant for performing the duties of this job and are considered "irrelevant" aptitudes: K - Motor Coordination, F - Finger Dexterity and M - Manual Dexterity.

B. Quantitative Analysis:

TABLE IV

Means (M), Standard Deviations (σ), and Pearson Product-Moment Correlations with the Criteria (r_1, r_2, r_3) for the Aptitudes of the GATB; N = 52

Aptitudes	M	σ	r1	r2	r3
G-Intelligence	142.9	13.9	.287*	.257	.306*
V-Verbal Aptitude	132.5	16.7	.368**	.245	.418**
N-Numerical Aptitude	135.1	14.1	.118	.152	.120
S-Spatial Aptitude	131.6	14.1	.224	.237	.200
P-Form Perception	124.4	20.2	.057	.122	.059
Q-Clerical Perception	133.1	19.8	.341*	.239	.384**
K-Motor Coordination	111.7	17.2	.169	.212	.152
F-Finger Dexterity	100.9	15.9	.071	.067	.081
M-Manual Dexterity	107.6	16.1	.078	.152	.055

**Significant at the .01 level
*Significant at the .05 level

C. Selection of Test Norms:

TABLE V

Summary of Qualitative and Quantitative Data

Type of Evidence	Aptitudes								
	G	V	N	S	P	Q	K	F	M
Job Analysis Data									
Important	X	X	X	X					
Irrelevant							X	X	X
Relatively High Mean	X	X	X			X			
Relatively Low Sigma	X		X	X					
Significant Correlation with Criterion	X	X				X			
Aptitudes to be Considered for Trial Norms	G	V	N	S		Q			

Trial norms consisting of various combinations of Aptitudes G, V, N, S, and Q with appropriate cutting scores were evaluated against the criterion by the tetrachoric correlation technique. A comparison of the results showed that B-1002 norms consisting of G-130, N-120 and S-120 had the best selective efficiency.

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VII. Validity of Norms (Concurrent)

The validity of the norms was determined by computing a tetrachoric correlation between the test norms and the criterion and applying the Chi Square test. The criterion was dichotomized by placing 33 percent of the sample in the low criterion group because this percent was considered to be the unsatisfactory or marginal workers.

Table VI shows the relationship between test norms consisting of Aptitudes G, N and S with critical scores of 130, 120 and 120, respectively, and the dichotomized criterion for Mathematician (profess. & kin.) 020.088. Persons in the high criterion group have been designated as "good students" and those in the low criterion group as "poor students."

TABLE VI

Validity of Test Norms for Mathematician (profess. & kin.) 020.088
(G-130, N-120, S-120)

N = 52	Non-Qualifying Test Scores	Qualifying Test Scores	Total
Good Students	5	30	35
Poor Students	9	8	17
Total	14	38	52

$r_{tet} = .64$ $\quad \chi^2 = 6.836$
$\sigma_{r_{tet}} = .24$ $\quad P/2 < .005$

The data in the above table indicate a significant relationship between the test norms and the criterion for the sample.

VIII. Conclusions

On the basis of the results of this study, Aptitudes G, N and S with minimum scores of 130, 120 and 120, respectively, have been established as B-1002 norms for Mathematician (profess. & kin.) 020.088. The equivalent B-1001 norms consist of G-135, N-125 and S-125.

IX. Determination of Occupational Aptitude Pattern

The specific norms established for this study did not meet the requirements for allocation to any of the existing 35 OAP's (revised 10/61). The data for this sample will be considered for future groupings of occupations in the development of new occupational aptitude patterns.