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The report describes a new kind of psychological testing machine, the Logical Analysis Device (LAD), and the attempts to use it for predicting academic grades of 97 freshmen engineering students at The Cooper Union in 1958, 77 of whom were re-tested in 1962. The LAD system allows a subject to proceed in his own way and at his own pace to solve problems which increase in complexity, while recording how the subject solves a problem and the level of difficulty he has mastered. As problems increase in complexity, the subject must develop a logical procedure for arriving at an effective solution. The research was based on two hypotheses, that freshman LAD scores would not change significantly during 4 years of college, and that freshman or senior scores could probably predict career choices within occupations followed by engineering graduates of The Cooper Union (electrical, chemical, mechanical, and civil engineering). A correlation of .14 between freshman LAD scores and 4-year college grades was too low to add to usual grade predictors. A correlation of .39 between senior-year LAD and college grades showed that there was a significant relationship between senior year LAD scores and grades. No significant differences in mean LAD scores of those preferring more theoretical careers as opposed to less theoretical careers was found in the 1967-1968 career reports. A later career follow-up is planned. (Author/WM)

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U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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LOGICAL ANALYSIS SKILL AS A TOOL FOR CAREER GUIDANCE

WALTER S. WATSON

The Cooper Union

New York City, New York

January 1969

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Preface

The original purpose of this investigation was to compare results of a new type of psychological test, the Logical Analysis Device (LAD), given to students before and after undergraduate engineering study, with performance of those students while in college. The purpose was modified to use career choice as the outcome we sought to predict and to include nine other predictor variables recorded prior to college study, as well as the results of six hours of tests, interviews and questionnaires obtained near the close of the fourth year of undergraduate engineering study.

The LAD was designed to record how a subject solves a problem as well as the level of difficulty successfully mastered. The form used in this research as well as the scoring system were developed by the Psychological Corporation of New York City from earlier forms used by Miller, John and Rimoldi at the University of Chicago.(12) Charles R. Langmuir, who was employed by the Psychological Corporation, directed the administration and scoring of the LAD tests. Richard Buchanan and David Fitzgibbins were responsible for attempts to improve the methods of scoring the LAD.

Many of the inter-relationships of the items used to assess this small group of 70-100 students are interesting to measurement specialists. However, the main goal of assessing the LAD as a predictor of career performance has not been reached as clearly as hoped for, due to the extended period of postgraduate study of a large proportion of the students. The author obtained estimates during 1967-68 from the students of the type of work they expect to be doing in five or ten years, but a graduate student's view of industrial management vs. industrial research, for example, may be quite different after he has been out of school for a few years. So, although this report concludes the research promised under the United States Office of Education sponsorship, the solution of the problem requires following the careers of these subjects for five or even ten years more to see which graduates pursue careers as researchers, salesmen, managers, developers, etc. before we can conclude how well the LAD and other predictors predict the actual career choices.

Acknowledgments

The author is indebted to the Psychological Corporation of New York City for their financial support of this research, for the use of the LOGICAL ANALYSIS DEVICE (LAD), for scoring the LAD tapes, and for two major attempts to improve procedures.

The senior-year testing (other than LAD) was directed and the results analyzed by Henry L. Rosett, M.D. and Herbert Robbins, Ph. D. of Mount Sinai Hospital, New York City. Doctor Rosett and Burton L. Nackinson, M. D., also of Mount Sinai, conducted and classified the senior-year interviews. Prof. Jacob I. Cohen of New York University gave the Mount Sinai researchers statisfical advice. Prof. Morris I. Stein, also of New York University, gave advice and permitted us to use some of his personality test and questionnaire materials.

The Mount Sinai research was given financial support by the National Institute of Mental Health.

Chapter I

Summary

The Logical Analysis Device was used to test the problem solving ability of 97 freshmen entering the Cooper Union School of Engineering in 1958 and again just before 82 of these freshmen graduated in 1962. It was expected that high scoring students would get higher grades while in school and choose more theoretically demanding careers than would low scoring students. The freshman and senior year measurements were pursued to determine how early the aptitude for logical analysis could be measured by the LAD. Most prior studies with the LAD had been made with mature adults at the peak of their careers.

The two major goals were improvement of the selection of engineering students and improvement in the career choices of engineering school graduates. Our hypothesis that there would be a high correlation between LAD scores and grades while in engineering school was not confirmed. The correlation between 1958 LAD scores and 4-year cumulative rating was only .14, which is much too low for guiding or selecting individuals. The 1 hour 1962 LAD did correlate .39 with 4-year college grade average. This was significant at the .01 level, but looking backward cannot help student selection.

The second hypothesis has not been confirmed as of a 1967-8 follow-up of the careers of 62 of 82 graduates, since there is no statistically reliable difference between the mean LAD scores of those planning on theoretically oriented careers in research or science and mathematics teaching as opposed to those entering sales management and other less theoretical careers. (See Table I)

<u>Table I</u>

Mean-Group LAD Scores for 60 Who Reported Career Choices in 1967 and for the Balance of the Entering Class

	Career Reported				No Career Data			
	High Theory: Research and Teaching		Moderate Theory: Sales, etc.		Grad.		Not Grad.	
LAD	Mean	No.	Mean	No.	Mean	No.	Mean	No.
1958	10.8	39	11.0	21	8.9	18	9.6	19
1962-1 Hr.	11.6	39	11.6	20	10.4	18	10.8	4
1962-1½ Hr.	12.7	39	13.0	20	11.8	18	12.5	4

The mean 1958 LAD score of the 19 students who left Cooper Union prior to graduating was 9.6 which is lower than the average 10.8 for the 39 graduates planning high theory careers, and the 11.0 for 21 graduates planning lower-theory careers. However, the 18 graduates who failed to report on career plans in 1967-8 were lowest of all with an average 1958 LAD of only 8.9. None of these averages differ significantly from each other at the .05 level and all of the means are higher and less diverse in 1962.

It is possible that real statistical differences among the general population of engineering students are concealed by the limited diversity within this high aptitude group. It is also possible that five years after graduation is too soon to identify career choices in a group, the majority of whom are expected to average seven years before completing their Ph D in engineering or science.

The 1 hr. 1962 LAD results have been included in several factor analytic studies of all the tests, interviews and career choices of the seniors. The LAD showed modest communality with an Embedded Figures Test, Spatial Relations and a Mechanical Ingenuity Test. It also loaded slightly on the factor dominated by mathematical and verbal reasoning. Although our hypotheses about the values of the LAD as a single predictor of success in engineering studies, or later careers appears to be unproven there is still a possible usefulness of this test as one of a set of factors which are related to career choice. This hypothesis will be tested when the experimental subjects are interviewed by telephone in a 1970 career follow-up. This date should permit completion of Ph D studies by most subjects, thus allowing a less restricted choice of careers.

Chapter II

Introduction

The Cooper Union consists of two small, private tuition-free colleges in the midst of several million people. Each college has always faced a surplus of candidates seeking admission and Cooper Union has, during most of its hundred year history, used entrance tests to choose those who showed the greater promise as students of engineering and science, or of art and architecture.

When Drs. Carl C. Brigham and E. L. Thorndike were hired in the 1920's to improve the entrance testing procedures, they initiated a program of testing which included a try-out of new tests side-by-side with familiar tests. Almost every year since that beginning, the Cooper Union has included one or more experimental tests in the battery given to those seeking admission. However, the new test has not been used for selection of students until some years later when the experimental students have completed enough years of college study so that predicted behavior could be validated against actual behavior.

In 1958, the Cooper Union School of Engineering received 933 applications for admission to the 97 places available in the freshman class. Using the College Board Scholastic Aptitude Tests (SAT) scores and high school average, (modified by double weights in grades in mathematics, physics and chemistry), the better 500 candidates were invited to come to Cooper Union for a day of competitive testing in March 1958. This day of testing included 3 College Board Achievement Tests, physics, chemistry and advanced mathematics, as well as 2 experimental tests, the Curtis Sentence Completion Test and 3 sections of the Yale Test Battery, Part III Verbal Reasoning, Part IV Quantitative Reasoning and Part VII Mechanical Ingenuity.

During the Summer of 1958, the Psychological Corporation of New York City offered to test these same engineering freshmen to assist in the validation of a newly developed LOGICAL ANALYSIS DEVICE (LAD). The test was given to each of the 97 freshmen during the week before classes opened in September 1958. They were also given a half-hour block-counting spatial relations test since this test had shown promise in earlier research.

The original plan called for a repetition of the LAD when the 1958 freshmen became seniors in 1962 to see if these test scores had reached a stable plateau as early as the freshman year of college, or if maturation or engineering studies would produce significant changes in LAD performance.

A testing device suitable for laboratory study of problem solving procedures had been developed about 1953 at the University of Chicago by Miller, John and Rimoldi. They called their equipment P.S.I. Apparatus. This laboratory equipment had been redesigned for field testing of occupational groups by the Psychological Corporation of New York City and renamed the Logical Analysis Device (LAD). Preliminary trials of the LAD on computer programmers, switchboard trouble shooters and sub-groups of the medical profession indicated that the LAD was a possible indicator of those whose occupation required an orderly, analytic approach to problem solving as opposed to others using more wholistic or intuitive problem solving methods. (see p.58)

Chapter III

Collecting The Data

The Logical Analysis Device (LAD) is a machine system which allows a subject to solve a series of problems at his own pace and in his own way. As the problems increase in complexity it becomes necessary for the examinee to develop some systematic (logical) procedure for recording or arranging the bits of data gleaned from the machine in order to arrive at an effective solution to the problem. After an examiner gives the examinee instruction, demonstration and an observed experimental trial of the LAD, the examiner retires and the subject works in isolation with complete freedom as to pace and procedure. A remotely located printer and timer records step-by-step the examinee's search for a solution. We were limited by funds for examiner time in 1958 so we limited each student to a 1-hour time limit, but in 1962 with more adequate funding we extended the time limit for each student to 90 minutes as had been customary in earlier research with the LAD. Because of the remote recording feature of this machine-type testing we could and did derive both a 60-minute and a 90-minute score for the 1962 examinees.(7)

A picture of the part of the LAD seen by the student is included on page 58 of this report. The panel seen in the picture holds a circular array of nine lights arranged around a center light. Each of the nine lights in the circle has an associated button which will, when pressed, activate that light and it may also assist or prevent the lighting of other lights as follows:

1) Facilitory: Light A can be followed by the lighting of an associated light B during the following time sequence.

2) Inhibitory: A prevents B from lighting during the following time sequence.

3) Combination: When buttons near to lights A and B are pressed simultaneously, C will light in the following time period.

When the center light is lit using a sequence of only a specified three of the nine buttons, the problem is solved.

The first step in solving the problem is to learn by trial and error a combination of steps involving all nine buttons which result in lighting the center light. The second step involves analysis of what is usually an unnecessarily involved routine so that unneeded steps may be eliminated and the center light lit by use of only three specified buttons.

To be sure the examinee has not accidentally reached a solution, the examiner may ask for a verbal explanation of one or more steps or he may observe the use of code to record observations.

For a more complete description of the operation of the LAD see C. R. Langmuir 1960.(11)

In 1958, the cost of testing and scoring one student with the LAD was about $40.00. It would be prohibitive to consider such an expensive testing procedure for the admissions process at Cooper Union, where we usually examine 500 to 800 candidates to fill a class of 100 freshmen. Even using the test on 80 seniors would be more expensive than most tests for students seeking career guidance.

However, it was our assumption that if the LAD was successful in separating the freshmen who belonged in engineering school from others who would not succeed in such studies, or if its use at the senior level predicted which graduates would do well in research careers as opposed to other graduates whose careers would deal with people, as in selling or management, or perhaps other graduates who would leave the technical field entirely; then test builders could construct mass-testing devices which duplicated to a large extent the fundamental areas measured by the costly, individually administered LAD. A sample of such techniques would be a test where the examinee erases an opaque covering over a chosen answer to discover the validity of his choice. The more expertly he proceeds in a series of choices the fewer answers need-be uncovered. The individually administered Binet test of intelligence is likewise expensive, but it led to the development of hundreds of paper and pencil intelligence tests which suffice for most situations and which cost far less to administer.

In January 1962 while plans were being made for giving LAD tests, to the seniors who had entered Cooper Union in 1958, a research team from the Organization Psychiatry Division of Mount Sinai Hospital approached Cooper Union with a proposal to see if any of our experimental tests would be helpful in their efforts to improve the job placement of scientists in industry. Their findings will not be included in this report unless related to the LAD test.

They were also interested in the connection between various cognitive controls and career choice in engineers and scientists. They decided to join with Cooper Union in testing and interviewing the 1962 senior class and to participate in matching their test and interview data against the career development of these students. The students were paid ten dollars each for participating in three hours of group testing, about three hours of individual testing and a one hour structured interview by one of two psychiatrists. The senior-year tests and interviews were conducted between the end of classes in May and graduation in early June of 1962. The group tested included 70 who completed the 4-year curriculum on schedule, 5 who were still attending Cooper Union but were not yet ready to graduate and 6 who had separated from Cooper Union but were attending nearby colleges and willing to return for re-testing on the LAD. The two girls and those out of school who were re-tested on the LAD were not included in the other senior year tests and the interview. One graduating senior did not take the senior-year tests.

Each student interviewed agreed to permit tape recording of the interview so that each of the two interviewers could rate the entire class on personality functioning, adaptation and defenses.

The students completed an autobiographical questionnaire developed by Morris I. Stein covering family background, personal development, school career and growth of scientific interest.

Two cognitive controls were assessed to see if they were related to choice of engineering major or to later choice among engineering-science careers. These controls were field articulation and physiognomic perception. Cognition includes such ego functions as perceiving, recognizing, judging and reasoning. Individual consistances or styles have been observed and it was our hypothesis that such styles or patterns of intellectual behavior could be associated with ego structures which determined career preferences.[3,4,5]

Field articulation has been described as the ability to focus attention without being distracted by competing, irrelevant stimuli. Earlier studies have shown that

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persons with high field articulation are more active in dealing with their environment, have a sophisticated, differentiated body image and selective control over emotional impulses as opposed to those with low field articulation who exhibit more massive repression of impulses, general passivity, and primitive undifferentiated body images. Rationalization is more often associated with high field articulation than with low.

The other cognitive characteristic which was assessed for members of this group was physiognomic perception. This has been defined by Werner[28] as a mode of perception in which objects are predominantly regarded through the motor and affective (or emotional) attitudes of the subject. Children who talk to their dolls or imaginary playmates and adults who angrily kick the flat tires on their automobiles are examples of seeing the world through a high physiognomic mode of perception, while the boss who thinks of his employees as barely distinguishable from the machine they operate in his factory would be classed as low physiognomic.

Field articulation was measured by at least six of the tests in this research: The Logical Analysis Device, Draw-a-Person Test, the Stroop Color Word Test, the Written Association Test, The Embedded Figures Test, and the vocabulary subtest of the Wechsler Adult Intelligence Scale. A single test, The Psysiognomic Cue Test, devised by Stein, Stern and Lane[25] was used to measure the second factor.

Our students were rated by one or two faculty members who knew them and they rated each other on the number of ideas, quality of ideas, originality of ideas, communication of ideas, research aptitude, industry and on personal liking. The seniors also completed the Thurstone Interest Schedule, the Stein Working Conditions Questionnaire and repeated the Curtis Sentence Completion Test they had taken as freshmen.[2]

It may be easier for the reader if we tabulate the titles of the various kinds of data collected before proceeding with a brief description of each item.

I <u>1958 Freshman-year Data</u>

4-year High School Average Grade, weighted heavier on math and science subjects.

5 College Board Test Scores:
SAT Verbal, SAT Math, Advanced Math, Chemistry and Physics.

6 Experimental Test Scores:
The LAD - 60 min. limit, the Curtis Sentence Completion Test, Spatial Relations with block counting type problems and 3 scores from the Yale Test Battery: Part III, Verbal Reasoning, Part IV, Mathematical Reasoning and Part VII, Mechanical Ingenuity.

II 1962 Senior Year Data

LAD 1 hour and 90 min. limits
New Test - Watson's Imagination Test
Mount Sinai Research Data
- 45 Min. interview and following day, dream report
- WAIS Vocabulary Test
- Draw-A-Figure Test
- Color-Word Interference test
- Free Association Test
- Embedded Figures Test (EFT)
- Kent-Rosanoff Word List
- Thurstone Interest Schedule
- Stein-Biographical Questionnaire
- Stein-Working Conditions Questionnaire
- 1965-California Personality Inventory - collected by mail

III Criterion Data

Grades - Undergraduate and graduate, 1962 Ratings - Faculty rated seniors on: number, quality, originality and communication of ideas, on aptitude for research, on industry and on personal liking.
Senior Students rated seniors on same items as faculty.

The high school average, the College Board Test scores and the LAD do not require further description.

The Curtis Completion Form was listed and described in the catalogs of the publisher, Science Research Associates, Chicago during the period of this study. It is now out of print. It consists of 52 sentence stems to be completed as the examinee chooses. High scores reflect unusual numbers of responses involving feelings of antagonism, self-pity, uncertainty, escape, fantasy and frustration, or a fear of response lest undesirable feelings be displayed.(2)

Spatial Relations was measured by a Cooper Union test of 24 piles of blocks like similar sections of the old College Board Spatial Test.

Yale Educational Aptitude Test was originally a battery given to guide admitted Yale students among various curricular offerings at Yale. Later it was released to the Educational Records Bureau of New York City for commercial distribution. The Verbal Reasoning and Quantitative Reasoning sections appeared to be more dependent on analytic thinking than the SAT Verbal and Mathematics Tests, while the Mechanical Ingenuity section was potentially helpful in spotting the boy more used to analyzing problems in real machinery, as opposed to verbal or mathematical problems.(1)

The author's Imagination Test has never been copyrighted. It consisted of 10 basic outline shapes such as a side view of a cigarette. The examinee was asked to search his imagination for as many real objects which contained each shape and to sketch each such subject. For example: the cap of a fountain pen, one section of a banded fuel pipe, a handle of a dresser drawer, etc., etc. Scoring consisted of a count of the total number of objects attempted less those with obvious distortions of the original outline, such as changing the cigarette outline to be pointed at one end.

The Mount Sinai tests and interviews will be described in the reports of Rosett, et al.

Chapter IV

Findings

We started the research with two hypotheses, first that freshman LAD scores would be relatively unchanged during 4 years of college, and second, that the freshman-level scores, (or others taken in the senior year) could be useful predictors of career choices within the various occupations followed by engineering graduates of The Cooper Union. It should follow as a corollary, that students who left college before graduation because they felt unsuited for engineering studies would have lower LAD scores than others who graduated. Among those who graduated, those choosing research should show higher LAD scores than others in sales, management, development or teaching.

In Table II, the reader can see by inspection that all occupational groups who stayed for re-testing in 1962 made significant gains during the 4 years of study. The "E" group, who shifted to non-engineering, non-science occupations and the group which failed to supply occupational data were also the two lowest scoring LAD groups at the time of freshman testing. However, they were not enough lower than our 1958 "B" group to explain why these students left Cooper Union while others stayed and raised their LAD scores to almost ceiling levels.

When the author prepared Table II he noted the absence of scores in the "15" category during the 1962 testing session so he prepared Table III to compare the 1958 test scores. It is clear that all students who scored 15 in 1958 scored either 14 or 13 on their second attempt in 1962, while the 14's either scored the same or dropped.

The 13's stayed at the same average while the 12's showed an 0.8 increase in average. The author guesses that this represents a changed scoring procedure rather than a real loss in performance for those at the top of the scale. The higher level of performance on the second test for those scoring below 12 on their first attempt rules out a general lack of motivation as a reason for any losses on the second round of testing.

Table II

LAD SCORES FOR 1958 AND 1962* VS 1966-68 REPORTED OCCUPATION

A-Research
B-Development
C-Technical Service & Sales
D-Technical and Math Teaching
E-Other (non-Technical)
F-Out and No Report

OCCUP	A		B		C		D		E		F		E & F	
LAD	58	62	58	62	58	62	58	62	58	62	58	62	58	62
15	2	0	3	0	0	0	1	0	1	0	0	0	1	0
14	5	7	1	10	3	6	1	1	0	2	1	0	1	2
13	2	12	2	5	2	3	0	4	0	1	0	0	0	1
12	3	4	2	7	3	2	0	0	2	1	1	1	3	2
11	1	2	2	2	3	3	0	0	0	0	0	1	0	1
10	5	1	3	1	3	2	1	0	2	0	0	1	2	1
9	3	0	2	1	0	0	1	0	2	0	1	0	3	0
8	2	1	4	1	0	0	0	0	2	0	1	0	3	0
7	4	0	7	0	2	0	1	0	1	0	4	0	5	0
6	0	0	1	0	1	0	0	0	2	0	0	0	2	0
N	27	27	27	27	17	16	5	5	12	4	8	3	20	7
MEAN	10.9	12.7	9.9	12.5	11.0	12.5	11.0	13.2	9.3	13.3	8.8	11.0	9.2	12.3

* 90 Min.

Table III

FREQUENCY COMPARISON

1958 LAD SCORES VS 1962* LAD SCORES

1958 SCORES	1962 SCORES 6	7	8	9	10	11	12	13	14	15	1958 SUMS
15								3	3		6
14						1		4	5		10
13						1		2	3		6
12						1	3	4	2		10
11								2	4		6
10					1	2	2	4	2		12
9							2	3	2		7
8					1		4	1	1		7
7			2	1	2	2	4	3	2		16
6					1	1					2
1962 SUMS	0	0	2	1	5	8	15	26	25	0	82

* 90 Min.

Table IV was prepared from initial returns to a career questionnaire mailed to the research students in May of 1968, supplemented by replies to 1966 and 1967 correspondence in a few cases where no 1968 returns were received. The Table I Research group was now divided into Basic "A" and Applied "B" and teaching was split into Science-Engr-Math "E" and those teaching history, etc. were grouped under "F" for other careers. Sales was now clearly listed under the Technical-Service-Engineering category which was "D" on this round of questions.

It is apparent by inspection of Table IV that a relatively low score on the LAD in 1958 did not indicate inability to prepare for research or engineering career. Note that students with 7 of the 10 lowest LAD scores report "A", "B" or "C" careers.

However, all but 4 of the 49 of these respondents tested again in 1962 had lifted their LAD scores to 11 or higher, and the 9 who were headed for theoretical research had 1962 LAD's of 13 or 14.

The general pattern is apparent also in Table III where 51 of 82 tested in 1962 had scores of 13 or 14 and 74 out of 82 scored in the 4 point range of 11-14. Roughly similar results were found in research into spatial relations and engineering grades and on-the-job aptitude tests. Engineers on-the-job and senior-student-engineers were significantly more skilled in dealing with spatial test problems than the general public who presented similar verbal IQ measurements. However, at the time of entrance to college, these same seniors had presented a much wider (and lower) range of spatial test skills.

It seems reasonable to the author to conclude that the type of problem-solving skill measured by the LAD is probably essential for most technical-mathematical research, production, design and teaching careers. However, a low score at college entrance does not prove that the student is unable to acquire the needed skill in college. We do not yet have proof that a low score at graduation from college bars such careers. The four or five subjects with scores below 10 who still planned on research or design-oriented careers may have found areas of research or design where LAD skill is not essential, just as we train color-blind artists who design

Table IV

LAD SCORES FOR 1958 AND 1962* VS 1968 ESTIMATE OF 1970 OCCUPATION

A-Basic Research
B-Applied Research & Pilot Projects
C-Production & Process Engineering
D-Sales & Technical Service Engineering
E-Teaching: Engrg-Sci-Math
F-Other - Non Engineering - Non Math

	OCCUPATION													
	A		B		C		D		E		F		SUMS	
LAD	58	62	58	62	58	62	58	62	58	62	58	62	58	62
15	1		1		2		1						5	0
14	3	6		9	1	2		3	1		1	2	6	22
13	1	3	3	3	2	4		1		2			6	13
12			3	4	1	1	1			1			5	6
11	1		2	2	1	1	1			1			5	4
10	2		4	1			1		1				8	1
9			1	1					1		1		3	1
8			2	1						1	1		3	2
7	1		4		1				1		1		8	0
6			1						1				2	0
N	9	9	21	21	8	8	4	4	5	5	4	2	51	49
MEAN	12.0	13.7	9.7	12.5	12.5	12.9	12.0	1[illegible].8	9.2	10.6	9.5	14.0		

* 90 Min.

glass formations, etchings, type-faces and work in many areas of design where color distinctions are not essential. Or these low LAD students may have false hopes for success in an area where they lack the needed skill.

The author plans on a further career follow-up of this class in 1970. It is our hope to be able to pin-point more precisely the career functions of each student and to distinguish the more and less successful performances in the various careers.

Two measures of reliability of the LAD were recorded. A comparison of the two judges scoring the 1958 test results showed a correlation of .90.

The second measure of reliability involved comparison of the 1958 scores with the 1-hour re-test scores in 1962. This correlation was .683. To the author this seems very satisfactory when he considers the restriction of range of ability resulting from the initial selection for admission to Cooper Union and the further restriction resulting from the four years of engineering study directed towards lifting all of the students to a point near or at the ceiling of this test. The correlation of the 1-hour 1958 LAD test with the 1½ hour 1962 LAD was .502.

In Table V one can see the median LAD scores arranged in rows by branch of engineering studies, and in column A all freshmen tested in 1958, in column B the freshmen scores of those who graduated and in columns C and D the 1 hour and 1½ hour senior-year LAD scores as re-measured in 1962.

Table V

MEDIAN LAD SCORES

Course	A Tot. '58	B Grads '58	C '62-1 Hr.	D '62-1½ Hr.
Chem	9.0	9.8	10.4	12.0
Civil	9.3	9.3	11.0	12.6
Elect	10.0	11.0	11.8	13.3
Mech	10.9	10.9	11.6	13.3
ALL	10.1	10.2	11.2	12.9

Although none of the medians in the rows or columns differs at the .05 level of significance from the remaining items, there are trends worthy of note. The maximum difference of 1.7 between curricular group medians in column B, or of 1.4 in column C was greater than the 1.0 difference between the median scores for all students in columns C and B. Or again looking at column B, we find that the electrical and mechanical freshmen have median scores of 11.0 and 10.9 while the senior chemicals in column C have a median score of only 10.4. We did not expect any group of seniors to score below freshmen and there is no data from entrance test scores or grades while in school to explain this differance between our chemical engineering majors and our other students. On College Board tests or on freshman grades the chemicals clearly outscore both the mechanical and civil groups. Finally we note that a median of 12.9 on the 90 minute 1962 test is too close for comfort to the 1962 ceiling of 14.0. These observations suggest the desirability of studying the differences among other samples of engineering curriculum groups on other campuses and in larger quantities if feasible so that we can be sure the differences were not an accident.

How well did the LAD predict engineering grades? The 1958 LAD had an r. of .28* with freshman grade average, and .14 with the 4-year cumulative average. The 1962 one-hour LAD showed an r. of .39* with the 4-year cumulative which is far from equal to a .61* which we found between our usual predictor (HSR plus CEEB tests) and cumulative grades for four years at Cooper Union. It is apparent that no senior-year test can offer much aid in selecting freshmen, unless the test also has validity at the pre-freshman level.

Every student who started at Cooper Union in 1958 was offered $12.00 to repeat the LAD and take other tests in 1962. 75 out of 76 students still attending Cooper Union responded and 6 others out of 20 still living and out of school volunteered to return for re-testing.

In Table VI we group the 81 who returned for 1962 tests under the heading "Repeaters" and the 15 who did not return under the heading of "Research Drop-Outs".

*Significant at .01 level

Table VI

DISTRIBUTIONS OF LAD SCORES FOR 1958 AND 1962

LAD Score	REPEATERS 1958	1 Hr 1962	1½ Hr 1962	Research Drop-Outs 1958
*14	16	16	25	2
13	6	10	26	-
12	8	8	15	2
11	7	22	7	-
10	12	6	5	2
9	8	12	1	2
8	6	4	2	1
7	16	3	-	4
6	2	-	-	1
5	-	-	-	1
N	81	81	81	15
Mean	10.36	11.27	12.59	9.20

* In Tables VI through IX, LAD Ratings of "A+" and "A" have been combined into one "A" rating and assigned a score of 14 to bring the 1958 scores more nearly into alignment with 1962 scores when 14 was the top score. One student who died in 1959 is not included in this table.

A glance at Table VI shows only a modest mean gain between the 1958 1 hour test and the 1962 1 hour test from 10.36 to 11.27. However, the effort made to arrive at a fair assessment under a 1 hour time limit may have made the 1958 ratings more like those given for the full 1½ hour test session in 1962. If so, the presence of 66 students in the top three categories in 1962 out of a possible 81 is a significant change from the 30 of this same group given one of the top three ratings in 1958. In fact there was so little variability left in the 1½ hr. ratings that for most of our data comparisons we used the 1962 1 hr. ratings instead of the longer measure.

The 9.20 mean for the research drop-outs is not statistically different from the 10.36 for the 1958 scores of those who stayed in school. However, the difference is in the expected direction.

In Tables VII through X we present further attempts to find differences among the four curricular groups. However, the 19 to 21 students in each group are such a small sample that refined statistical analyses of the differences did not seem worthwhile.

On academic tests such as the SAT our four curriculum groups ranked Electrical, Chemical, Mechanical, Civil. However, on the LAD the Mechanicals move up to second and the Chemicals are third in 1958 and fourth in both 1962 LAD averages. The Mechanicals even exceed the Electricals when we include the two research drop-outs in their 1958 average score

In Table VIII the Chemical group appears somewhat heavy at the upper and lower ends of the scale. Having eleven students in the 6 and 7 score range may account for nine Chemical students leaving Cooper Union before graduation compared with no more than four from any of the other 3 sections. We have no way of knowing whether the gap between SAT scores and LAD performances of this Chemical group and the reverse gap for the Mechanicals was an accident or perhaps characteristic of other similar Chemical and Mechanical engineers.

The column of research drop-outs shows a slightly lower mean than those who completed the research but inspection of the distribution of drop-outs on the four groups in Tables VIII and IX reveals no clear pattern.

The distributions of 1962 scores by departmental majors is shown in Tables X and XI. The Chemicals had six ratings of 14 in 1958 on the 1 hour test (Table VIII) but can place only 2 in the 14 category in either of the 1962 test ratings. They show only .42 gain in average 1 hour score, the lowest of any of the four groups. The massing of the other three curriculum groups so close to the ceiling of the test scale on the 1½ hour test shows that the shorter time limit of 1 hour is a more effective procedure if <u>speed</u> of analytic thinking is important, while the other 1½ hour limit may be a better measure of analytic skill without regard to speed. This is commonly referred to as a power test.

Two separate studies were made to see if we could develop improved separation of the curriculum majors of of the prediction of grades in engineering school through the use of more refined methods of scoring the LAD. The first attempt was reported by R. Buchanan of the Psychological Corporation in June 1963 and in included in the appendix of this report as Item No. 1.

The second study was an attempt by Rosett & Robbins of Mt. Sinai and David Fitzgibbons of the Psychological Corporation to develop new LAD scoring techniques which would be more closely related to the Mt. Sinai personality, cognitive and intellectual factors.

Table VII

	LAD 1958 Test Scores			LAD 1962 Test Scores	
	Repeaters	Research Drop-Outs	Total	1 Hour	1.5 Hours
Chemical Engineers					
N =	19	7	26	19	19
Mean =	10.16	9.14	9.88	10.58	11.84
Civil Engineers					
N =	21	4	25	21	21
Mean =	9.33	9.50	9.36	11.00	12.26
Electrical Engineers					
N =	20	2	22	20	20
Mean =	11.00	8.00	10.74	11.55	13.20
Mechanical Engineers					
N =	21	2	23	21	21
Mean =	10.95	11.00	10.96	11.57	13.14
Total					
N =	81	15	96	81	81
Mean =	10.36	9.20	10.06	11.27	12.59

Table VIII

DISTRIBUTION OF 1958 LAD SCORES

LAD Scores	For Chemical Engineering Students			For Civil Engineering Students		
	Repeaters	Research Drop-Outs	Total Group	Repeaters	Research Drop-Outs	Total Group
14	6	1	7	-	1	1
13	1	-	1	1	-	1
12	1	1	2	3	1	4
11	-	-	-	3	-	3
10	2	1	3	3	-	3
9	1	-	1	3	-	3
8	-	1	1	2	-	2
7	7	2	9	5	1	6
6	1	1	2	1	-	1
5	-	-	-	-	1	1
N =	19	7	26	21	4	25
Mean =	10.16	9.14	9.88	9.33	9.50	9.36

Table IX

DISTRIBUTION OF 1958 LAD SCORES

LAD Scores	For Electrical Engineering Students			For Mechanical Engineering Students		
	Repeaters	Research Drop-Ours	Total Group	Repeaters	Research Drop-Outs	Total Group
14	7	-	7	3	-	3
13	2	-	2	2	-	2
12	1	-	1	3	1	4
11	-	-	-	4	-	4
10	2	-	2	5	1	6
9	3	1	4	1	-	1
8	2	-	2	2	-	2
7	3	1	4	1	-	1
6	-	-	-	-	-	-
5	-	-	-	-	-	-
N =	20	2	22	21	2	23
Mean =	11.00	8.00	10.74	10.95	11.0	10.96

Table X

DISTRIBUTION OF 1962 LAD SCORES

LAD Scores	For Chemical Engineering Students 1962 1 Hour	For Chemical Engineering Students 1962 1.5 Hours	For Civil Engineering Students 1962 1 Hour	For Civil Engineering Students 1962 1.5 Hours
14	2	2	4	5
13	2	5	2	6
12	1	5	2	5
11	4	4	5	2
10	4	2	1	2
9	4	-	5	-
8	1	1	1	1
7	1	-	1	-
N =	19	19	21	21
Mean =	10.58	11.84	11.00	12.26

Table XI

DISTRIBUTION OF 1962 LAD SCORES

LAD Scores	For Electrical Engineering Students 1962 1 Hour	For Electrical Engineering Students 1962 1.5 Hours	For Mechanical Engineering Students 1962 1 Hour	For Mechanical Engineering Students 1962 1.5 Hours
14	5	9	5	9
13	3	6	3	9
12	3	4	2	1
11	7	-	6	1
10	-	1	1	1
9	1	-	2	-
8	-	-	2	-
7	1	-	-	-
N =	20	20	21	21
Mean =	11.55	13.20	11.57	13.14

Re-reading of the tapes that recorded the original 1962 1 hr performance by each student produced 27 new scores each possibly related to personality and cognitive style scores, or to ratings. None proved better than the original 1 hr score and none of the multiple correlations were significant at the .01 level.

However, a table of the simple correlations between the 1962 LAD 1 hr test and the other 19 non-LAD variables may give the reader a view of the efforts underway to group and inter-relate grouped items from our larger lists of independent measures of each student.

Table XII

CORRELATION BETWEEN 1962 LAD 1 HR TEST SCORE

AND

19 COGNITIVE AND INTELLECTUAL VARIABLES

		r.
1. Self Esteem	Personality Z Scores	.09
2. Driving Ambition		.15
3. Theoretical Abstract Interests		.05
4. Projective Self Esteem		-.15
5. Prefer Management to Exclusive Scientific Interest		-.30**
6. Low Autonomy		.10
7. Esthetic - Expressive		-.14
8. Obsessional Openness		-.07
9. "F" Scale		-.19
10. Ratings of Creativity by Faculty		.32**
11. Ratings of Creativity Given to Peers		.08
12. Ratings of Personal Liking from Peers		-.05
13. Phys-Cue A Score	Cognitive Z Scores	-.05
14. Phys-Cue B. Score		.00
15. Academic Achievement		.16
16. Physiognomic		-.04
17. Scanning		.07
18. Field Articulation		.37**
19. Abstract Reasoning		.27*

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

Items 1 through 8 in Table XII are Z scores based upon a nine factor analysis of the personality test (CPI) and interview rating data. Items 9 through 14 are the scores on individual personality tests or on ratings, while the final 5 items are based upon Cognitive style Z scores. We note that a high LAD is negatively related to a preference for management -.30 and positively related to faculty ratings of student creativity .32, to the Field Articulation Factor score .37 and to the Abstract Reasoning Factor .27. The first three are significant at the .01 level and the fourth at the .05 level.

One of several factor analyses of the cognitive and intellectual items in our data files was the basis of a paper(19) presented to the Educational Research Association of New York State at Albany in November 1966. It was our hypothesis that factor analyses of the school and college grades of our students and the related entrance test scores and personality test scores would reveal patterns of communality not readily apparent by inspection of the tests. This follows from studies such as (13) which show little or no correlation between college grades and a number of criteria of job performance. There has been increasing evidence that personality characteristics frequently are dominant in determining career success.

We hoped that grouping our data into a few groups of related items would produce Z scores for our students which would tie-in with career choices and career success even though none of the nineteen separate items analyzed was a useful predictor by itself. Prior research had led us to expect that three general areas of personality were related to engineering careers. These related areas of personality are also called cognitive control principles. They were: Field Articulation which represents a general ability to direct attention without distraction by opposing stimuli. We used an embedded figures test (EFT) for this factor; Scanning, or the ability to search one's mind rapidly and widely in a directed manner just as a good librarian finds more related references in a minimum of time. We used free association to the word DRY to evaluate scanning. The third cognitive control we called Physiognomic Perception. This represents a tendency to react to objects as symbols, or feelings, rather than as geometric or literal descriptions to measure this tendency. The test we used was called Physiognomic Cue. Literal, geometric descriptions were opposed to feelings in half the items and the other half of the items required

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a choice between literal descriptions and symbolic descriptions. A preference for a feeling response resulted in a high "A" score, and a preference for a symbolic response resulted in a high "B" score. The two responses were related, but distinguishable from each other and together they made up a total score which was opposed to a literal response.(22)

In Table XIII one can see the list of 19 items analyzed and the five factors resulting. The factor names are arbitrary titles selected by the author on the basis of the heavier beta weights in each column. Inspection of Factor I, which we called Academic Achievement, reveals that several items are not as closely connected to college grades as one usually finds them in correlational analyses of independent items. For example note: Yale Verbal Reasoning -08, SAT Verbal -04, Yale Mechanical Ingenuity -17, % Distant Units -12, CEEB Physics 05. However, note that "giving the common response" rates 39. From this data one could conclude that during the period 1958-62 the way to get good grades at Cooper Union did not depend very much upon reasoning or ingenuity.

The 1 hr. 1962 LAD loads with low positive weights on the first three factors but clearly belongs almost equally to factors IV (Field Articulation) and V (Abstract Reasoning). As companions in Factor IV the LAD 39, finds the Cooper Union average grade 37, CEEB Adv. Mathematics 42, the Embedded Figures Test -71, Block Counting Spatial 68, Yale Mechanical Ingenuity 56 and CEEB Physics at 30. The minus beta weight on the EFT results from using elapsed time as a score. A low score means high ability.

However, in Factor V which we have called Abstract Reasoning many of the factor IV items lose their association. Adv. Mathematics 33 is still there, while Yale Mech. Eng. 53, LAD 37, and CEEB Physics 24 are about the same as on the Factor IV. The new companions in Factor V are: Yale Verbal Reasoning 72, SAT Verbal 61, and Yale Quantitative Reasoning 45. The low loading of 04 for Cooper Union Average and -11 for high school average re-confirms our conclusions from Factor I. The differences in verbal and reasoning skills have little to do with grades in high school and college among such a narrow range of abilities found in this sample of engineering students.

Table XIII

Factor Loadings of Cognitive, Intellectual and Academic Achievement Variables

	I Academic Achievement	II Physiog. Percept.	III Scanning	IV Field Acticulation	V Abstract Reasoning	h^2
Cooper Union Average	54	-09	-22	37	04	49
High School Average	49	16	-20	-06	-11	32
CEEB: Advanced Math	44	01	18	42	33	51
Kent-Rosanoff Common Words	39	-18	-04	-07	-02	19
PCT: A Factor	-15	59	-03	14	-16	41
Color Word: Interference	06	53	-36	-04	-02	42
PCT: B Factor	-29	46	12	-09	02	32
Color Word: Recall	05	28	02	-08	02	09
Word Ass'n: % Distant Units	-12	07	59	-03	20	41
Word Ass'n: No. of Words	02	-15	57	-08	-09	36
Sophistication of Body Image	14	-04	-33	-21	04	17
Embedded Figures Test	06	10	-11	-71	08	53
CU Block Counting Spatial	-02	-06	-01	68	-07	48
Yale: Mechanical Ingenuity	-17	-01	-19	56	53	65
LAD: 1962 1 Hr.	14	12	11	39	37	34
CEEB: Physics	05	-18	-19	30	24	22
Yale: Verbal Reasoning	-08	-09	06	04	72	53
SAT: Verbal	-04	-08	-01	-09	61	39
Yale: Quantitative Reasoning	29	03	36	15	45	44
Random Number	30	01	00	-19	08	17
Random Number	-14	-24	04	16	-31	20
% Communal Variance	17	15	17	27	25	

The results of the interview session appear to be of peripheral interest to most readers of this study of the LAD with the exception that the same pattern of intense concentration needed to do well on the LAD or the Embedded Figures Test can be interpreted in quite a different light when such behavior reaches extremes. A skinny boy who would rather study than eat, looks good to his teacher and bad to his mother.

In an unpublished paper presented to his colleagues at Mt. Sinai in the fall of 1968, Henry L. Rosett, M.D. presented the results of a series of factor analyses and correlation studies which grouped 59 personality variables into 9 factors, the 19 cognitive variables were reduced to 6 factors and a 65 item Work Attitude Questionnaire completed by 60 of our subjects in 1967 was reduced to 7 factors.

It was his hypothesis that such clusters of related variables were more apt to lead to understanding of career choice and career success than the study of group means on individual variables such as IQ, LAD scores, etc.

Each of the 60 seniors who responded to the Work Attitude Questionnaire was given a Z score on each of the 15 predictor factors as well as the 7 WAQ factors. Such scores were derived from each student's score on the separate variables multiplied by the dominant beta weights of the variables participating in a factor.

In Table XIV below we list the multiple correlations resulting from 3 calculations. In the first row the cognitive factors alone were used to predict the 7 WAQ factors. Only factor VI - Administration reaches a statistically significant level. In the second row the personality factors alone were used to predict the WAQ factors and 3 of the 7 were significant at the 05 level or better. In the third row we see the results of using all of the cognitive and personality data to predict WAQ factors. The resulting correlations are higher, but the larger number of predictors increases the chances of accidental relationships so that we still find only 3 statistically significant correlations in row 3.

The hypothesis that clusters of predictors would be better predictors of clusters of Work Attitudes is upheld. We found no significant difference in mean LAD scores as predictors of those reporting theory oriented careers as opposed to sales, management, etc. But by this factor analytic grouping of predictor items and career preferences, we do find some significant relationships between variables assessed in the senior year, or earlier, and the students' work preferences five years later.

Table XIV

MULTIPLE R: WAQ FACTORS WITH COGNITIVE AND PERSONALITY VARIABLES

	WAQ Factors Dependent Variables						
Independent Variables	I	II	III	IV	V	VI	VII
Cognitive alone	.34	.21	.30	.28	.39	.50**	.33
Personality alone	.47*	.53**	.31	.38	.45	.59**	.30
Cognitive and Personality combined	.55	.59*	.44	.47	.59*	.71**	.49

* $p < .05$
** $p < .01$

WAQ Factors:
I = Professional reputation and status
II = Critical thinking
III = Practical experimentation
IV = "Playing with ideas" alone
V = Congenial and practical work
VI = Administration
VII = Intellectual independence

The reader may wonder what happened to the LAD in the grouping and re-grouping of our data. It was one of the individual variables used to determine two of the cognitive variables, Field Articulation and Abstract Reasoning. In Table XV which follows, we find no correlations for these two factors which are significant at the .05 level, although 6 of the total of 42 correlations do reach at least the .05 level.

The partial correlations between personality factor scores and the 7 WAQ factors are presented in Table XVI while the partial correlations for the 15 cognitive and personality factors are presented in Table XVII. The names of the factors are arbitrary titles selected by the author to identify the leading determinants of each factor. The reader may wish to examine some items which came near to the .05 level of significance as well as those reaching or exceeding it. For example in Table XV Column V, the WAQ factor related to a preference for Congenial and Practical work shows a significant correlation of .26 with the Physiognomic Cue Test B score. But 3 other negative correlations of .19 or larger are also listed; -.19 for Academic Achievement, -.21 for Abstract Reasoning and -.20 for the PCT - A score. All three correlations suggest probable relationships that could be significant if our research population was larger, more diverse and more settled in their work. A proposed career follow-up in 1970 should produce more definitive career preference responses. Selection of a larger more diverse experimental population must wait for an entirely new study.

Table XV

PARTIAL R: INDIVIDUAL COGNITIVE VARIABLES WITH 7 WAQ FACTORS

Cognitive Variables	I	II	III	IV	V	VI	VII
Academic Achievement	-.26*	-.10	-.24*	.11	-.19	-.30**	-.18
Scanning	-.02	-.16	-.14	-.01	.06	-.19	.02
Field Articulation	.01	-.06	.13	-.05	.07	-.16	-.16
Abstract Reasoning	-.13	.11	.10	.14	-.21	-.12	-.03
PCT A	-.19	.09	.04	.19	-.20	-.26*	.19
PCT B	.09	-.07	-.10	-.20	.26*	.24*	-.18
Multiple R	.34	.21	.30	.28	.39	.50**	.33

* $p < .05$
** $p < .01$

Table XVI

PARTIAL R: INDIVIDUAL PERSONALITY VARIABLES

WITH 7 WAQ FACTORS

Personality Variables	I	II	III	IV	V	VI	VII
Self Esteem	-.08	.09	-.04	-.21	-.12	-.23	.02
Driving Ambition	-.02	.23**	-.16	-.12	-.12	.04	.02
Theoretical Independence	.01	-.01	-.03	-.16	-.16	-.36**	.17
Projective Self Esteem	-.33**	-.05	.12	-.20	-.20	-.22	.03
Non-Technical Verbal	.17	.11	-.03	.24*	.24*	.29*	-.03
Autonomy	.05	-.22	.19	-.12	-.12	-.10	.05
Active-Passive Role	-.12	-.04	.12	-.17	-.17	.09	.17
Obsessional Openness	.22	.25*	-.13	-.03	-.03	-.02	.03
F Scale	.26*	-.25*	-.01	.11	.11	-.05	-.04
Multiple R	.47*	.43**	.31	.38	.45	.59**	.30

* $p < .05$
** $p < .01$

Table XVII

PARTIAL R: COGNITIVE PLUS PERSONALITY VARIABLES

WITH 7 WAQ FACTORS

Cognitive plus Personality Variables	I	II	III	IV	V	VI	VII
Academic Achievement	-.27*	-.21	-.21	.18	-.10	-.23	-.25
Scanning	.03	-.19	-.18	-.01	.23	-.13	-.10
Field Articulation	.04	.08	.14	-.10	.12	-.11	-.24
Abstract Reasoning	-.05	.04	.19	.16	-.21	-.20	-.06
PCT A	-.18	-.06	.09	.18	-.09	-.27*	.12
PCT B	.03	-.12	-.14	-.16	.28*	.34**	-.15
Self Esteem	-.01	.16	.06	-.22	-.16	-.23	.12
Driving Ambition	.02	-.32**	-.15	-.20	-.12	.11	.11
Yheoretical Independence	.05	.06	.01	.07	-.22	-.40**	.21
Projective Self Esteen	-.35**	-.03	.13	.09	-.24	-.23	.03
Non-Technical Verbal	.13	.15	.08	-.12	.18	.06	-.21
Autonomy	-.01	-.23	.22	.05	-.07	-.12	.09
Active-Passive Role	-.14	-.02	.11	-.09	-.23	.16	.17
Obsessional Openness	.28*	.31*	-.09	.08	-.05	-.02	.03
F Scale	.26*	-.21	.07	.03	-.02	-.18	-.07
Multiple R	.55	.59*	.44	.47	.59*	.71**	.49

* $p < .05$
** $p < .01$

Chapter V

Conclusions

The author found that 51 of 82 retested engineering students had raised their freshman LAD scores to either the highest or next to highest category used by the 1962 scoring team and 74 of the 82 were placed in the top 4 scores of a potential 14 point range of LAD scores. From Table III we can see that 44 or over half of the 1958 scores were scores of 10 or less while only 8 of the same 82 students scored that low in 1962.

It seems reasonable to conclude that the improvement was produced by their 4 years of engineering mathematics and science study rather than by a practice effect or by maturation. The author recalled a similar outcome when spatial relations skills were measured before and after 4 years of engineering study. In that case, most of the change occured during the freshman year. Similar studies had revealed that high spatial skill was a distinctive characteristic of engineers on-the-job.

In Chapter IV a comparison of the LAD scores by curriculum areas among the 4 offered at Cooper Union showed some interesting differentials (Table V). The median LAD score of 9.0 for the chemical engineering majors was the lowest of the 4 groups and their final scores in 1962 median 10.4 on the 1 hr. list was also lowest. The median for all was 11.2. However, the median College Board test score for the chemicals was about ½ sigma above the civils and mechanicals. The mechanicals who rated near the civils on academic tests stood at the top of median LAD score in 1958 10.9 and equaled the EE's 133 on the 1½ hr. LAD in 1962. The electricals and mechanicals 13.3 came so near the ceiling on the 1½ hr. 1962 tests that a separate study was made of the percent of possible gain for each student (See Appendix - Buchanan). No viable conclusions were reported from this refinement in scoring.

Some correlational studies and some attempts to group the mass of personal and intellectual data into smaller clusters of related items were reported.

When the faculty rated the seniors on Creativity their ratings were positively correlated with LAD scores .32.

The correlations of LAD '58 with freshman grades .28 and with 4-year cumulative grades .19 were not as high as the senior-year 1962 1 hour test which reached a .39 with the 4-year cumulative.

These show a strong positive relationship similar to the correlationships regularly noted between spatial relations scores and engineering school grades even though later factor analyses regularly separated both the LAD and spatial test scores from factors containing the grades for classwork.

In Table XIII we presented a 5 factor analysis of 19 Cognitive, Intellectual and Academic Achievement Variables. Separation of School and College Averages from most Verbal and Quantitative Admission Test results was surprising. Only the College Board Advanced Mathematics and a tendency to give common responses on the Kent-Rosanoff Word List were associated with high school and college grades. On the other hand, CEEB Physics and SAT Verbal Scores, Yale Verbal Reasoning, Mechanical Ingenuity and Numerical Reasoning were associated with the LAD in a factor independent of grades. The other 3 factors centered upon scores on the Physiognomic Cue Test, Word Association and the Embedded Figures Test.

The LAD scores by themselves failed to predict career choices in 1967. The 19 who left before graduation had a mean score of 9.6 and the 18 not filing career reports scored 8.9. Both means are lower than the 1958 mean scores of the 60 subjects who did file a 1967 career report. 39 of the 66 reported careers with a high need for theory (teaching, research, etc.). They had a mean score of 10.8 in 1958 but the 21 reporting sales, management and other less theoretically demanding careers had a mean of 11.0 for their 1958 LAD scores. None of these differences in career group LAD means are significant at the .05 level.

Finally, Dr. Rosett's analysis of factored responses to a career choice questionnaire when correlated with cognitive and intellectual factor scores showed that such groups of test and attitude information were significantly correlated with clusters of attitudes toward occupation some 5 years later in 7 out of 21 relationships studied.

There seems to be little value in the LAD as a single predictor of success in engineering school or of career preference. However, groups of predictor variables combined and weighted by factor analysis and correlation techniques do show moderate success in predicting school grades and career choices.

Further experimentation with predictions based upon larger and more diverse populations seems justified. In view of the expense of administration there is not sufficient evidence of the value of the LAD to warrant including the LAD in the predictor variables of such extended studies.

ERIC

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APPENDIX A

Subject: Further Analysis of LAD Performance of Cooper Union Engineering Students - R. Buchanan

When 81 of the original 96 students were re-tested with the Logical Analysis Device, it was found that there was a general trend toward improvement in the ability of the students to solve the LAD problems. However, the students were given a one hour time limit when they took the test in 1958 whereas they were given 1.5 hour time limit on the 1962 re-test. In order to make the results more comparable the ratings were also evaluated on the basis of one hour performances. These one hour ratings also showed the general trend towards improvement. A summary of this data appears in Table XVIII below.

Table XVIII

Mean Improvement in LAD Rating

Group	N	Mean 1 hour Improvement	Mean 1.5 hour Improvement	Diff.
All engineers	81	.94	2.25	1.31
Mech. Eng.	21	.81	2.05	1.24
Elec. Eng.	20	.95	2.40	1.45
Chem. Eng.	19	.47	1.68	1.21
Civil Eng.	21	1.66	2.95	1.29

However, some students could not improve their ratings since they received the top rating in the 1958 test and the 1962 re-test. Accordingly, the mean improvement was calculated eliminating the scores of those students. The results appear in Table XIX below.

Table XIX

Mean Improvement in LAD Rating of Only Those Who Could Improve

Group	N	Mean 1 hour Improvement	Mean 1.5 hour Improvement	Diff.
All Engineers	74	1.03	2.49	1.46
Mech. Eng.	20	.85	2.15	1.30
Elec. Eng.	16	1.19	2.80	1.61
Chem. Eng.	17	.53	1.88	1.35
Civil Eng.	21	1.66	2.95	1.29

Since some groups started at higher mean levels than others, absolute improvement might be slightly misleading. Therefore, <u>the relative improvement</u> of each group was calculated (relative improvement = mean improvement/amount of improvement possible). The results of such calculations appear in Table XX below.

Table XX

Relative Improvement

Group	N	1 hour relative improvement	1.5 hour relative improvement
All engineers	74	.28	.68
Mech. Eng.	20	.28	.71
Elec. Eng.	16	.40	.93
Chem. Eng.	17	.14	.49
Civil Eng.	21	.32	.57

Additional gross indications of improvement were also calculated: (1) highest problem attempted in equivalent total time; (2) problems completely solved in equivalent total time; and (3) highest problem solved in equivalent problem solving time (to correct for differences in instructional time). The results appear below in terms of the number of individual students in each of the three assessment categories.

Table XXI

Additional Problems Tried and Solved in Equivalent Times

Category of Improvement		Additional Problems				
	N	-1	0	+1	+2	+3
(1) Highest pbm.attmpted	81	6	40	31	4	
(2) Highest pbm.solved (total time)	81	3	29	38	10	1
(3) Highest pbm. solved* (pbm-solving time)	74	3	25	41	3	2

* Used only those who could improve

2-Level Problem Analysis

The results of the previous analyses show that not only did students generally improve their total performance, but that they also attempted and solved more problems in the same time. In order to see whether some groups made better use of their previous experience than others and whether certain groups could be discriminated on the basis of their approach and total performance on the LAD, the highest problem solved by most of the students (the 2-level problem) was analyzed in terms of the process by which each student solved the problem.

The initial approach made use of a measure called the Analysis-Synthesis ratio (A:S ratio). An analytical move is one which consists of one or more button pushes in the same time period, while a synthetic move consists of two or more button pushes in more than one time period. Therefore, the analysis-synthesis ratio is the number of analytical moves to one synthesis move used by the student in solving a problem. The A:S ratio score for problem 2 was derived for each student for each session, and the scores were correlated. The correlation was essentially zero. Further analysis of the data showed that the students tended to be more analytical the second time as measured by the A:S ratio. In order to see whether the increase was general or related to the general improvement shown by the students, the total group was divided into four groups: (1) those who improved their performance; (2) those who did not improve their performance; (3) those who could not improve because they received the top rating in both the 1958 and 1962 tests; and (4) those who did more poorly on the second test. Improvement was separated into two categories, improvement for equivalent time in both tests (1 hour 1962) and improvement with increased time in the second test (1.5 hour 1962). The results of such comparisons are shown below in Table V.

Both the improved group (1) and the group that could not improve (3) showed expectedly higher A:S ratios on the second test. However, the group that did not improve had lower A:S ratios for the second session. It would seem that this group should show equivalent A:S scores for both test sessions if the ability to solve the problem is a function of the degree of analytical ability exhibited and if the A:S ratio is an accurate assessment of that ability. The fact that the difference is not in the expected direction suggests that either the students were less analytical the second time but still managed to solve the problem or the A:S is not a representative measure of analytical ability. A non-significant correlation (R = .173) between the 1962 one-hour LAD rating and the A:S ratio score for that session tends to support the latter contention.

Table XXII

Mean A:S ratios by Categories of Improvement

Group	N	A:S ratio 1958	A:S ratio 1962	Difference 1962-1958
1962 1-hour rating - 1958 rating				
(1) Improved	44	6.63	8.50	1.87
(2) Not improved	10	6.66	4.41	-2.19
(3) Not improved (top rating 1958 & 1962)	7	7.03	9.86	2.83
(4) Did more poorly	16	5.58	5.13	-0.45
Total	77*			
1962 1.5-hour rating - 1958 rating				
(1) Improved	55	6.39	7.56	1.17
(2) Not improved	5	8.70	6.33	-2.37
(3) Not Improved (top rating 1958 & 1962)	8	6.80	8.75	1.95
(4) Did more poorly	9	7.85	5.79	-2.06
Total	77*			

* 4 of the 81 students did not attempt the 2-level problem in 1958.

Nevertheless a second analysis using the A:S ratio was an attempt to identify student majors by their mean A:S ratio scores. The results of such analysis are shown below, along with the mean improvement scores of those groups.

Table XXIII

Mean A:S ratios for Major Fields of Concentration

Group	N	Mean A:S Ratios 1958	Mean A:S Ratios 1962	Difference 1962 1958	Mean Imp. 1962-1958 1 hr	Mean Imp. 1962-1958 1.5 hr	Relative Imp. 1 hr	Relative Imp. 1.5 hr
Mech.Eng.	20	8.71	9.58	.87	.85	2.15	.28	.71
Elec.Eng.	18	6.50	7.40	.90	1.19	2.80	.40	.93
Chem.Eng.	19	5.34	5.80	.46	.53	1.88	.14	.49
Civl.Eng.	20	8.74	6.89	-1.90	1.66	2.95	.32	.57

For the first three groups the results seem reasonable. The greater the increase in the A:S ratio, the greater the increase in the LAD rating is shown by that group. However, the group that exhibited greatest absolute change (Civil Engineers) and the next to greatest relative improvement for 1 hour 1962, also showed a lower mean A:S ratio the second time. Again there is the possibility that the A:S ratio is not an accurate measure.

If a student made a great number of highly redundant, illogically organized analytical moves, his A:S ratio would be spuriously higher than that student who needed to make only a few key moves to discover the key relationships. In order to correct for this possibility, a new measure called the NRA:S ratio was devised (non-redundant analytical-synthesis ratio). This was the number of non-redundant analytical moves to one synthetic move, rather than just the number of analytical moves to one synthetic move. This ratio was then correlated with the one-hour performance rating for 1962. The results, along with the previous correlation are given below.

Table XXIV

NRA:S and A:S vs. 1962 (1-hour) LAD Ratings

Measure	N	r
NRA:S	77	.381
A:S	77	.173

The predictive ability of the new measure is better than the original A:S ratio. In order to see if this ratio could also predict some change in performance, the difference between the rating of the students on the test-retest situation was correlated with the change in the NRA:S. The r = 0.574. This indicates that those students who adopted more analytical approaches in the second session were also those students who did better on the total rating.

Since the elimination of redundancy for the A:S ratio resulted in better predictive power for that type of measure, a Redundancy Ratio was derived for each of the students who attempted the 2-level problem in both sessions. Correlations were run between redundancy (that is the number of non-redundant analytical moves/the total number of moves) and the ratings for the 1958 test and the 1 hour performance ratings on the 1962 test. Also, the change in redundancy was related to change in overall test performance. The results are summarized in Table XXV.

TABLE XXV

2-Level Problem Redundancy Ratio and Lad Ratings

Measure	vs. LAD test	N	r
Redun. Ratio	1958	74	.581
Redun. Ratio	1962 (1-hour)	74	.570
Redun. Change	rating chge.	74	.379

It can be seen that this measure seems to be a stable predictor of total performance rating, but it is less proficient in its ability to predict improvement in performance. An alternate analysis of comparable tapes for the second level problem was undertaken using as a measure an analysis called the utility index (U). The utility index of a particular analytical question was derived from the formula

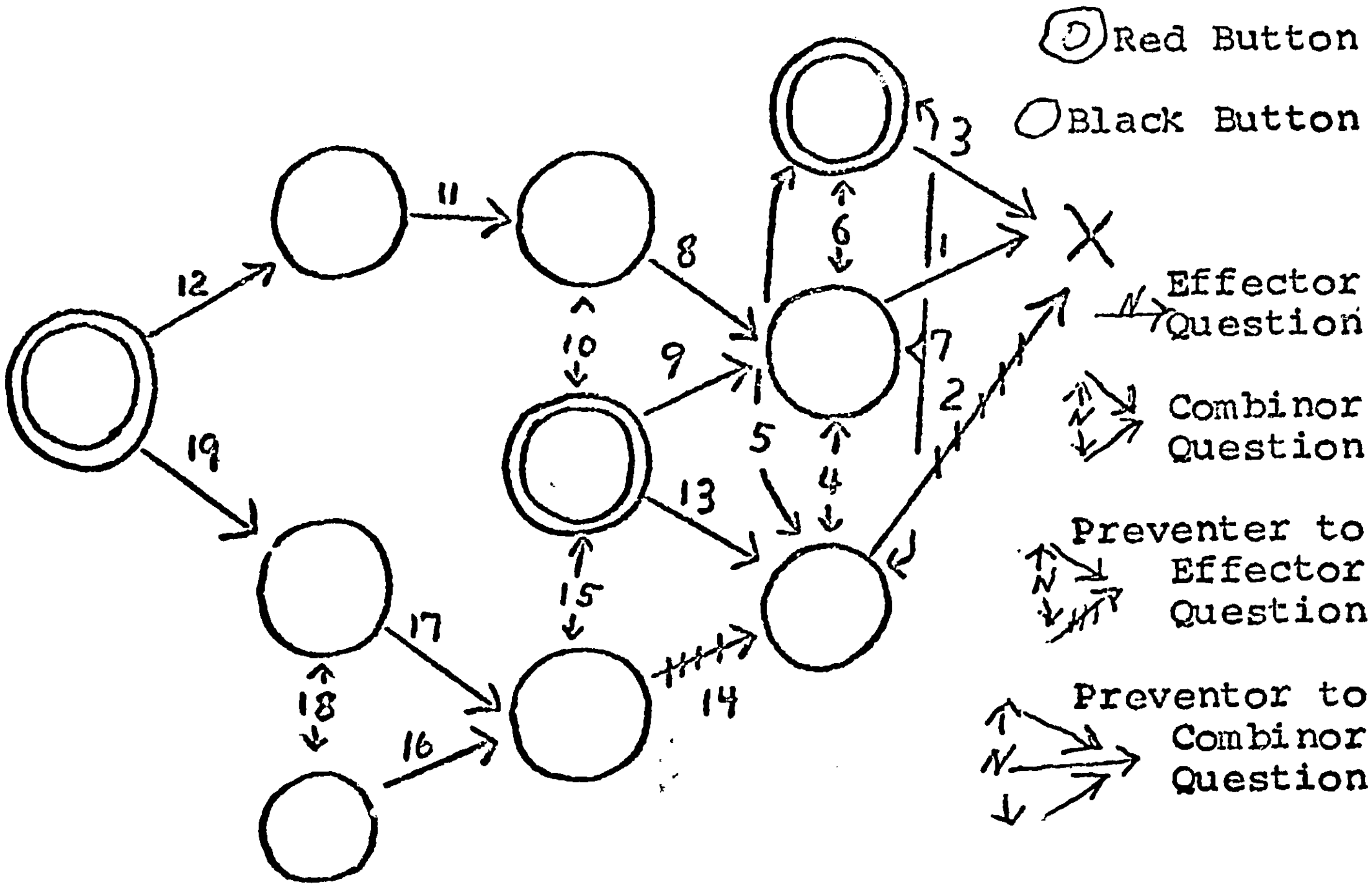
$$U = \frac{NQ}{N}$$

where NQ = the number of subjects who asked a particular question and N = the number of subjects in the sample.

The best utility index for a particular question would be 1.00; that is, a question that is asked by all the members of the sample. Of the 19 possible analytical questions (see Figure 1) necessary to solve the problem, only the combinor relationship necessary to light the center light was asked by all the students. The range of mean utility scores ran from 1.00 (for the combinor to the center light) to 0.37 (the check on the preventor to the center light).

Figure 1

2-level Problem Diagram and List of Utility Scores for Key Questions

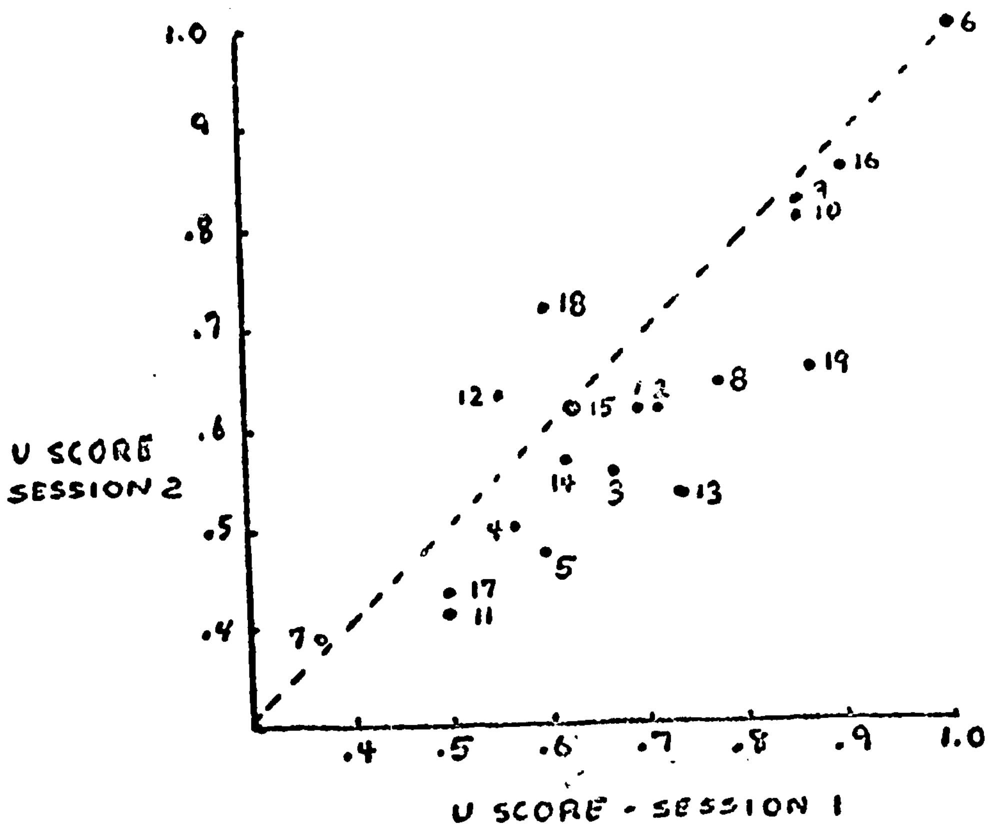


Question #	1	2	2	4	5	6	7	8	9	
Mean U Scores	.67	.68	.61	.52	.51	1.00	.37	.80	.86	
Q #	10	11	12	13	14	15	16	17	18	19
M.U.S.	.79	.44	.57	.63	.59	.63	.86	.47	.66	.76

The utility indexes were also derived for each session and were plotted on a graph to show their range of importance and relative change in importance (see Figure 2). The ordinate was the utility index for session one and the abcissa was the utility index for session two. If a question was of equal importance the second time, it would fall on the line bisecting the 90° angle of the X and Y axis. If it was less important, it would fall below the line, and if it was more important, it would fall above the line.

Figure 2

Plotted Change in U Scores



Only three questions were more important the second time while 15 were more important the first time. Two of the questions (#6, #15) were equally important in both sessions. However, the fact that there were some questions that were more important the second time and some questions that were less important the second time give clues to the increased ability of the students to solve the 2-level problem. By asking key questions a greater proportion of the time, the students eliminated much unnecessary and low powered analysis in favor of analyzing those elements of the problem which were most crucial to the solution of the problem. Correlating the U scores for both sessions gave a rho= .925 and an r = .88. That is, the more important questions maintained their order of importance, but became relatively more important. The students apparently realized the importance of certain analytical moves the second time.

Because of the fact that students with certain majors differed in terms of their mean LAD achievement and improvement (Table I, II and III), and because of the fact that some of their achievement could be predicted by the number of necessary analytical moves that they made, there was the possibility that the students could also be separated in terms of the efficiency of their approach to the LAD problems that might tend to correlate with their choice of major field. Accordingly, U scores were calculated for each question for each major, and the data was subject to an appropriate analysis. While there was a predictable significant difference between questions by their U scores, there was no significant effect on the U scores by major.

An alternative approach using the data was then investigated. It was suspected that persons asking more of the key questions would stand a better chance of achieving a higher rating than those asking fewer key questions. Therefore, the total number of key analytical questions was tallied for each student (for session 2) and the resultant score (NRA--sum of non-redundant analytical questions) was correlated with the LAD rating. The r= -.502. This low, negative and significant correlation is surprising. Apparently, as was the case with the first A:S ratio, the measure did not discern between students who had to ask only a few very important questions to solve the problem and those students who needed to ask a large number of less key questions in order to solve the problem. Since it seemed that those questions involving more complex relationships should be more important than those involving less complex and less important relationships, the ENRA was readjusted to a new score (WNRA--sum of weighted non-redundant analytical questions). In this scoring system, those questions involving two button pushes were given a weight of two, while those using just one button push were given a weight of one. These scores were correlated with the LAD rating and resulted in a smaller yet still negative correlation (r = -.245). Again this measure failed because of its inability to discern between a few key moves used in an elegant approach to the problem and the large number of moves used in a low-powered analytical approach.

An alternate analysis approach would assign the mean U score value to each non-redundant analytical move made by the student. The total of these scores would be his total U score, and this value would be divided by the number of non-redundant analytical moves the student made. The resultant score might then be related to the LAD rating. By making use of the optimally weighted values of each analytical question, such a measure would discern between the low-powered analysis of the poor problem solver and the efficient, high-powered analysis of the sharp person.

However, because major field of concentration could not be identified by approach to the LAD problem, it would be hard to justify the additional number of computations necessary to obtain this optimally weighted problem-solving score.

Summary of 2-level Problem Analysis

In terms of the present analysis, it can be seen that the improvement shown by the students is explicable in terms of their ability to grasp and use their understanding of the logical structure of the LAD problems. Those students who improved tended to be more analytical and more selective in their analysis of the problems. Those students who had done well on the first test generally did even better on the second. Those students who either did not do as well or did not improve their performance generally were less analytical and had greater difficulty grasping and using the efficient approach to the problem. In terms of separations, both the Mechanical Engineers and the Electrical Engineers made the most of their previous experience with LAD given an extra half hour, while the Chemical Engineers did not improve their performance as greatly. While objectification of the tapes shows that certain forms of analysis tended to predict performance and improvement, such analysis was not able to identify, with any certainty, students of different major choices. While the analysis could identify some of the students, this could also be predicted by their overall achievement. Certainly groups can not be identified only by their approach to a LAD problem, at least with the present kind of analysis. From the data it is doubtful that persons with certain major choices have any particular mode of approach. Those who have chosen Mechanical or Electrical Engineering tend to do better, while those who have chosen Chemical or Civil Engineering tend to do more poorly. Those who do better with the closed logical system of LAD tend to do better because they adopt the system more easily than those who do not do so well. Were there equally adequate types of approaches to the same problem it might be possible to discern approach differences or preferences. In the absence of that freedom, those who do well have adopted the most efficient system while those who do not do as well have not.

LAD Performance in Relation to Other Measures

Since the restrictions of the LAD test limit the analysis of the results, various investigations were undertaken relating to the total LAD performance ratings to other measures of the students' achievement.

The Cooper Union Entrance Scores were correlated with 1958 and 1962 LAD ratings for the 81 students who took both tests. In addition to correlating these scores for the group as a whole, correlations were also run for each of the four major fields of concentration. The results are summarized in Table XXVI.

Table XXVI

LAD ratings vs. Cooper Union Entrance Scores

Groups	N	1958 LAD ratings r=	1962 LAD ratings r=
All engineers	81	.070	-.140
Mech. Eng.	21	.080	-.030
Elec. Eng.	20	-.045	.430
Chem. Eng.	19	-.033	-.690
Civl. Eng.	21	-.063	.066

The correlations of the 1962 LAD ratings and the Cooper Union Entrance Scores for each of the majors would be interesting were it not for the fact that the Ns were small and a few cases spuriously distorted the data. The essentially zero correlations with the 1958 LAD ratings present a far more realistic picture.

The LAD ratings were also correlated with the entrance tests given before the freshman year in addition to measures of the students' achievement. The results are given below in Table XXVII

Table XXVII

1958 LAD ratings vs. Test Scores and Academic Achievement

LAD vs.	Entering Class (N=96) r=	Drop-outs (N=20) r=
SAT (Verbal	.138	.147
(Numerical)	.103	-.084
Yale (III)	.323	.393
(IV)	.220	-.125
(VII)	.358	-.007
Adv. Math	.550	.212
Cum. Ave. (N=81)	.136	

In order to see if improvement in LAD performance was related to either the Cooper Union Entrace Score or scholastic achievement, these measures were correlated, and the results appear below.

Table XXVIII

LAD Improvement vs. Entrance Scores and Academic Achievement

LAD Improvement vs.	N	r
Cum. Ave.	72	.062
CU Ent. Score	72	.039

Summary

LAD ratings and improvement have moderate relationship with only a few of the other measures and essentially no relationship with the others. The only relationships that seem to have some predictive utility are those relationships which are moderately present for the students who complete their training at Cooper Union, and not present for those students who leave the engineering program. (see Yale IV, VII and Advanced Math, Table XXVII) Unfortunately, the small size of the drop-out sample and the diversity of reasons for leaving the engineering program make such a contention tenuous at best.

An explanation for the few significant relationships is related to the level of ability exhibited by the Cooper

Union freshmen. The mean LAD rating in 1958 was high (B-) with almost 19% of all the students and almost 20% of those who took the re-test receiving the top rating. In addition, the Engineering students were a highly select group -- the lowest SAT score being in the 590 range. A normal distribution of ratings would hardly be expected from such a group.

Since the LAD rating is a reflection of the student's ability to grasp and utilize the closed logical system of the problems, those students who achieved high rating would be expected to exhibit the logical tendencies identified by a thoroughgoing analysis of their approach to the problems. Where the abilities brought into play in the solution of the LAD problems are similar to the abilities needed to achieve certain academic endeavors, it would be expected that achievement in those endeavors would be reflected in the LAD performance. It is possible, therefore, that identifying the abilities needed for certain classroom tasks could be done with the Logical Analysis Device. However, the use of the LAD test as a predictor of total academic performance does not seem to be supported by the present data nor the foregoing analysis.

APPENDIX B

Word Attitude Questionnaire (WAQ)
Used for 1967-68 follow-up to 1962 graduates.

WORK ATTITUDE QUESTIONNAIRE - (WAQ)

PROJECT 1726 - COOPER UNION

Code Number ______

Date ______

Part I

In looking forward to your future career, what activities are most important to you? Please rank-order the following activities or abilities according to the extent to which they are important to you. Assign a rank of "1" to the activity that is most important to you, and a rank of "13" to the least important. Be sure to rank all items and do not assign the same rank to more than one.

	Ranks
Originating and developing ideas for useful products or processes.	______
Effectively communicating ideas and findings through writing or talking to other professional persons (scientists and/or engineers).	______
Planning for and solving problems of facilities, services, budgets, or personnel for research.	______
Being able to get along with colleagues and superiors in the research organization.	______
Developing and carrying out the scientific or engineering ideas of others.	______
To stay with a company for a long time.	______
Independently carrying out your own ideas.	______
Carrying out the routine aspects of the work efficiently and accurately.	______
Knowing the right people.	______
Planning and directing the research programs of other professional men.	______
Working in close cooperation with salesmen, customers, contractors, etc.	______
Effectively "selling" ideas and findings through writing and/or talking to management or customers.	______
Making original discoveries of theoretical value for the growth of scientific and/or engineering knowledge.	______

WAQ

Code Number__________

Part II

The technical work of scientists and engineers covers a broad range of activities. In the next 5 years, about what percent of your time would you guess will be directed toward each of the following purposes (either your own work, or work for which you are responsible)? Enter nearest 5-10%. FILL ALL SPACES.

		Percent of work
A. Research (discovery of new knowledge either basic or applied)..		______%
1. General knowledge relevant to a broad class of problems.........................	______%	
2. Specific knowledge for solution of particular problems..................	______%	
Subtotal should equal item A..........	(______%)	
B. Development and invention (design of particular products or processes; translating knowledge into useful form).....................................		______%
3. Improvement of existing products or processes...........................	______%	
4. Invention of new products or processes...	______%	
Subtotal should equal item B.........	(______%)	
C. Technical services to help other people or groups..		______%
5. Testing; use of standardized techniques to obtain data needed by others..............	______%	
6. Consultation, trouble-shooting..........	______%	
Subtotal should equal item C.........	(______%)	
D. 7. Teaching and/or supervision of college students..		______%
E. 8. Other purposes: ______________________________		______%
Total time should add to 100%.................		(______%)

Code Number__________

Part III

Some individuals are completely involved in their technical work--absorbed in it night and day. For others, their work is simply one of several interests. How involved do you feel in your work and study? CHECK ONE answer.

___Not much involved

___Slightly involved

___Moderately

___Strongly

___Very strongly

___Completely; the most absorbing thing in my life

Part IV

Scientific and engineering activities call for a variety of abilities, some of which are listed below. Being as objective as you can, how do you feel you stand on each ability, compared with others of similar training in the same field?

Please MARK ACROSS EACH SCALE at the appropriate point. Thus a mark at "67" means: "on the average" you feel you stand above two-thirds of others in the field.

I stand approximately above:

1% 10% 30% 50% 70% 90% 99%

(low) (high)

A. Technical ability (sound training, know-how, grasp of field) 10 30 50 70 90

B. Creativity (imagination, originality; thinking of better ways to do the job). . .

C. Methodicalness (thoroughness, carefulness, precision). . . . .

D. Energy (hard work, drive; meeting schedules; large output) . . . .

E. Critical ability (sound evaluation of ideas; clear thinking) 10 30 50 70 90

Code Number________

Part VI

Listed below are different kinds of opportunities which a job might afford. If you were to seek a job, how much importance would you personally attach to each of these (disregarding whether or not your present job provides them)?

CHECK ONE in each line	Importance I would attach: Slight or none	Moderate	Considerable	Great	Utmost
A. to make full use of my present knowledge and skills	___	___	___	___	___
B. to grow and learn new knowledge and skills.	___	___	___	___	___
C. to earn a good salary	___	___	___	___	___
D. to advance in administrative authority and status.	___	___	___	___	___
E. to work with colleagues of high technical competence . .	___	___	___	___	___
F. to have congenial co-workers as colleagues	___	___	___	___	___
G. to work under chiefs of high technical competence.	___	___	___	___	___
H. to associate with top executives in the organization. .	___	___	___	___	___
I. to build my professional reputation.	___	___	___	___	___
J. to work on difficult and challenging problems.	___	___	___	___	___
K. to work on problems of value to the nation's well-being. .	___	___	___	___	___
L. to have freedom to carry out my own ideas.	___	___	___	___	___
M. to contribute to broad technical knowledge in my field .	___	___	___	___	___
N. Other:					
______________________	___	___	___	___	___
______________________	___	___	___	___	___

ERIC

Part V

Code Number________

Scientists and engineers may differ widely in their characteristic approach to their work--both the kinds of problems that attract them, and the way they go about the task. How closely does each statement describe the approach you typically prefer to use.

(Note: try to ignore limitations set by particular conditions of work, and describe the approach you prefer.)

CHECK ONE in each line	How closely statement describes me: Not at all 0%	15%	30%	Moderately 50%	70%	85%	Completely 100%
A. I mainly prefer problems that are interesting in themselves.	___	___	___	___	___	___	___
B. I mainly prefer problems that will help to build my professional reputation.	___	___	___	___	___	___	___
C. I mainly prefer problems that will lead to advancement in organizational status.	___	___	___	___	___	___	___
D. I prefer areas where I can be fairly sure of some acceptable results, even though not spectacular.	___	___	___	___	___	___	___
E. I prefer to map out broad features of important new areas, leaving detailed study to others.	___	___	___	___	___	___	___
F. I prefer to probe deeply and thoroughly in selected areas, even though narrow	___	___	___	___	___	___	___
G. I'm rather a lone wolf; prefer to work by myself.	___	___	___	___	___	___	___
H. I'm a strong team man; work best in collaboration with colleagues	___	___	___	___	___	___	___
I. I'm effective as a "right hand man," carrying ball for a more experienced advisor.	___	___	___	___	___	___	___
J. I prefer to develop my ideas "inside my head," before testing them against nature. .	___	___	___	___	___	___	___
K. I am stimulated by problems met in trying to control the external environment	___	___	___	___	___	___	___

ERIC

Code Number ________

Part V (Continued)

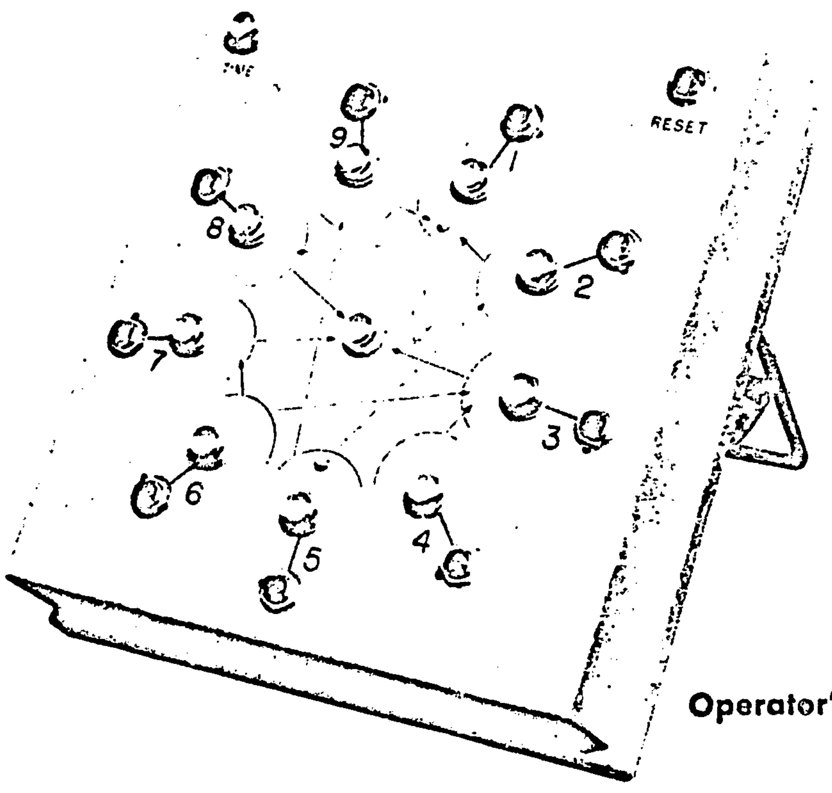
CHECK ONE in each line	0%	15%	30%	50%	70%	85%	100%
L. I prefer to spend enough time to find general principles that apply to many situations.	___	___	___	___	___	___	___
M. I prefer to find immediate solutions to specific problems.	___	___	___	___	___	___	___
N. I find it fruitful to utilize abstract concepts several steps removed from direct observation	___	___	___	___	___	___	___
O. I prefer to find out all I can by observation, before trying to generalize.	___	___	___	___	___	___	___
P. I like to bring about order and simplicity in chaotic or complex material.	___	___	___	___	___	___	___
Q. I enjoy finding loopholes and contradictions in previous efforts to explain an area. .	___	___	___	___	___	___	___
R. I prefer to plan a long-range series of related tasks, which I follow more-or-less systematically.	___	___	___	___	___	___	___
S. I prefer to alter my direction from week to week as new developments arise.	___	___	___	___	___	___	___
T. Some of my friends think that my ideas are impractical if not a bit wild.	___	___	___	___	___	___	___
U. Straightforward reasoning appeals to me more than metaphors and the search for analogies	___	___	___	___	___	___	___
V. I think I take primarily an esthetic view of experience .	___	___	___	___	___	___	___
W. Barring emergencies, I have a pretty good idea what I'll be doing for the next ten years	___	___	___	___	___	___	___

ERIC

APPENDIX C

Information about

The Logical Analysis Device



Operator's Display Panel

The Logical Analysis Device is used to test problem-solving ability. The Psychological Corporation has developed standardized procedures for using LAD for selection and assignment of personnel and for applied research in the best placement of highly trained and talented people.

The LAD problems are unambiguous examples of a completely defined logical system. They closely parallel the diagnostic or trouble-shooting situation. No specialized experience or knowledge is required.

The logical complexity of the LAD problems can be quickly changed. By presenting a series of increasing difficulty, it is possible to measure an individual's ability in organizing complex information and to observe his directness of attack, speed of work, recognition of logically useful information, activity when frustrated by an error, and other elements of behavior associated with problem-solving.

THE PSYCHOLOGICAL CORPORATION
304 EAST FORTY-FIFTH STREET • NEW YORK 17, NEW YORK

The Standardized Presentation of the LAD

Problem-solving situation tests can be put before a person in a large variety of ways. The Psychological Corporation has limited its attention to the development of the LAD as a method of evaluating personnel for critical job assignments – those for which special abilities and characteristic thinking habits are important.

The introduction of a person to the LAD logical system has been standardized in a form which creates an optimal situation for observing an individual's characteristic modes of attack on logical tasks. All the rules of the system are demonstrated, explained, and reviewed with practice exercises. A written summary is provided for reference, and the simplest, most effective method of solution is demonstrated. Questions may be asked of the examiner at any time. The individual being tested has complete freedom to work in any manner he prefers.

After the introduction which requires ten to fifteen minutes, the work is done in isolation without any personal interaction with or pressure from the examiner.

The problems are presented in a graded series of complexity. After each problem the examiner reviews the logical content of the exercise and demonstrates a simple, effective method of finding the solution.

The purpose of this careful presentation is to eliminate the possibility that the instruction or the nature of the task might be misunderstood. The examiner's function is to make certain that every person tested has been explicitly and repeatedly shown simple and effective methods.

The fact that many persons cannot or will not use demonstrated logical methods even when the methods of their own choice are ineffective indicates the kind of important individual characteristics that are identified by the LAD testing.

How the LAD Works

The nine lights in the circular display panel can be turned on by manual operation of the adjacent push-button switches. The target light in the center has no switch. The operator's first step in solving the problem is to find out by experimental trials which combination of lights has the effect of turning on the center light. He is aided in planning his trials by an information diagram consisting of arrows linking pairs of lights.

Prior to tackling a problem, he has been instructed that each arrow represents one of three possible cause-effect relations, and the meaning of the relations has been disclosed by actual demonstration on the device.

The second phase of the solution involves analysis and experiment to ascertain the effects of the arrow relations that are not directly associated with the target light.

The third and final step in the solution is achieved when the operator can control the automatic relations and turn on the target light by some sequence of operations, restricted to the three buttons numbered 4, 5, and 6. *This phase requires synthesis of all the information acquired in the analytical phases.*

Evaluation of the Performance

The rating of performance is accomplished by analysis of an objective printed record of the actual operations on the display panel. Several factors are observed. The number of problems solved in relation to the highest level of complexity attempted, and the time required, indicates the power of the individual. Scrutiny of the details of the performance on individual problems reveals whether the characteristic mode of approach was analytical or non-analytical. The objective scoring of each problem is supplemented by the examiner's record of the operator's understanding of the logical content of the problem. Individuals whose performance lies in the intermediate region between a consistently analytic and a totally non-analytic approach are described by such statements as the following:

"Initially analytic but abandoned analytic methods in the more complex problems."

OR

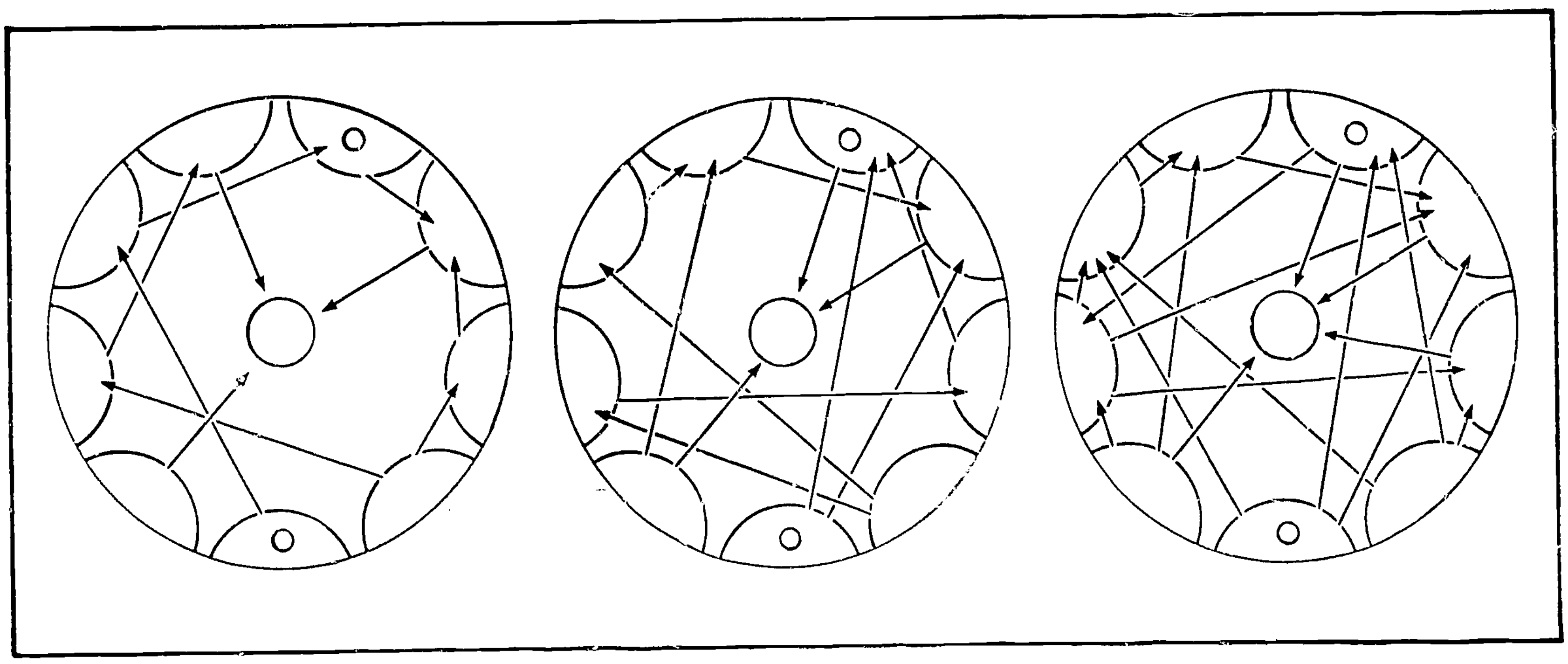
"The analytic approach used at the beginning of all problems was given up when the solution was not immediately demonstrated."

OR

"Analytical methods adopted when other methods failed to produce the solution."

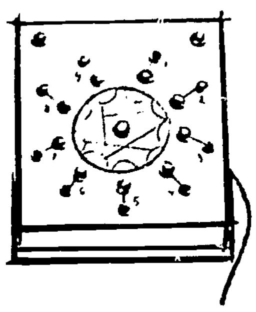
OR

"Some evidence of an effort to use analytical methods, but the process seldom carried through to a definite result."

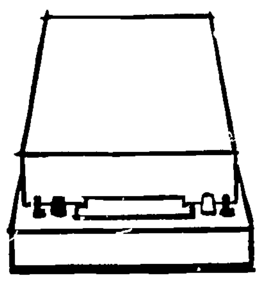


Three LAD Information Diagrams of Increasing Logical Complexity

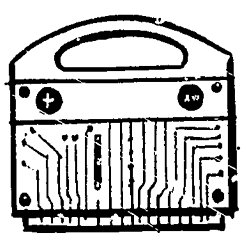
The LAD Consists of a Display Panel and Five Auxiliary Items of Equipment



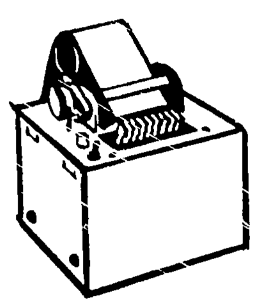
OPERATOR'S DISPLAY PANEL consists of nine lights arranged in a circle, each with an adjacent push-button switch and a tenth target light at the center of the circle which has no switch. A time indicator light and a re-set button are at corners of the panel.



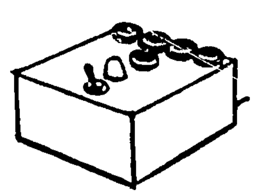
CENTRAL LOGIC UNIT contains the power supply required for all the equipment, the timing mechanism, and the switching circuitry.



PROBLEM PLUG BOARDS are printed circuit cards which may be quickly inserted in the central logic unit to change problems. Problem changes require only the few seconds necessary to extract one plug board and insert another.



DISCRETE EVENT RECORDER prints the number corresponding to every effective push-button operation. The printed tape provides a legible, complete, timed record of every action performed on the Operator's Display Panel.



EXAMINER'S CONTROL UNIT contains six switches which permit the examiner to print control information on the recorder.

The Complete system can be packed in two carrying cases.

The Logical Analysis Device is not offered for sale. A limited number of sets are available on lease for significant applied research.