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Prediction of Academic Success in Computer Programming and Systems Design Course Work

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ABSTRACT

The study investigated the ability of 17 intuitively selected cognitive and affective variables to differentiate between the academically successful and unsuccessful subject in regard to computer programming and system design course performance. Furthermore, the ability of Computer Programmers Aptitude Battery (CPAB) to predict academic success in programming and systems design was explored. The analysis, which employed factor analysis, stepwise regression and MANOVA, revealed that two variables--recognition of assumptions and diagramming --differentiated between the successful and unsuccessful system design students, whereas three variables--diagramming, test anxiety-worry and embedded figures ability--differentiated between the successful and unsuccessful programming student. The results suggested that the CPAB is a predictor of academic performance in programming and systems design. However, the factors identified herein as good differentiators not contained in the CPAB may merit consideration in the development of future standardized computer programming/systems design aptitude tests.

Note: This article is based on a paper originally presented at the first Data Con Educator Conference, St. Louis, MO, September 24, 1985.

INTRODUCTION

With accelerating usage of computers in both educational and business environments, providing effective instruction to potential data processing users is increasingly important. Unfortunately, not everyone may be suited to perform some of the high level tasks associated with the upper strata professional job titles within the computer science industry. Therefore, the ability to predict success in data processing training based on a number of cognitive and affective abilities could be helpful in screening potential applicants for computer science academic programs.

However, much of the research to date focuses upon prediction of achievement only in programming classwork (Burns, 1973; Williams, 1976; McLaughlin, 1981; Irons, 1982). Thus, systems analysis, an area critical to the provision of efficient computer systems is often overlooked from a measurement standpoint. This may be due to the fact that systems analysis is often viewed as an extension of programming since historically people filling systems design positions began their careers as programmers.

Furthermore, in regard to skills required in these job titles there appears to be a certain degree of differentiation. The programmer often works on a specific program that makes up only a small portion of the entire system, whereas the system analyst must have a more global orientation in that he/she must design a system that will be made up of a multiple programs that interact with each other. This trend of giving priority to prediction of success in programming has appeared in the business environment as well. For example, one of the more widely used standardized instruments in the prediction of vocational success in data processing, the Computer Programmers Aptitude Battery (Palormo, 1974), presents adequate technical data in regard to prediction of success in the field of programming. However, since this instrument has been validated as a predictor of programming potential primarily in a business environment, its relative predictive power in an academic environment has not been totally established. In addition, the test battery assumes an overlap between the skills required for systems analysis and programming, meaning that the instrument's ability to predict success in systems analysis requires further validation.

Therefore, the present study was designed to validate empirically which of a number of intuitively selected cognitive and affective abilities are required for success in second year academic computer programming and system analysis courses. More specifically, an attempt was made to determine the relationship between and among cognitive and affective variables required for achievement in both a computer programming course (Advanced COBOL) and a systems analysis course (Advanced Systems Analysis and Design). Furthermore, an attempt was made to ascertain the ability of the Computer Programmers Aptitude Battery to predict academic success in computer programming and systems analysis.

Procedure

In the summer of 1984 a meeting of instructors in a data processing program revealed that the high achievers in the systems analysis courses were not necessarily the same students that performed well in the programming courses. To analyze the cause of this situation properly a two-prong approach was used in selecting variables for the study. First, some of the instructors felt that differences in achievement were due to factors in the cognitive domain, particularly those abilities associated with the analysis and synthesis levels. Second, some of the committee suggested the differences might be related to affective considerations, especially in regard to anxiety resulting from course expectations. The major class requirement that was contained in the system design classes and not in the programming courses was a written document that suggested a solution to a given system design case study. This report was to be compiled over the entire semester and was weighted 25% in regard to final semester grade determination.

The instructors then reviewed a list of both cognitive and affective

variables that had proved pertinent in previous research designed to select items related to success in academic computer science related courses. From this list the group of instructors selected a number of both cognitive and affective factors that they felt might clarify the differences observed between programming and system design performance. The success that Beleutz, 1975 had in the validation of cognitive style as a predictor of success in mastering computer programming led to the inclusion of cognitive style. To ascertain differences in cognitive style the Group Embedded Figures Test (GEFT) (Witkin, Oltman, Raskin and Karp, 1971) was employed due to its ease of administration and adequate reliability and validity data. The work of Hunt and Randhawa, 1973 that ascertained a relationship between some of the subtest of the Watson Glaser Critical Thinking Appraisal (WGCTA) and performance in an academic computer science training situation prompted the group to include all five subtests of the WGCTA (Watson and Glaser, 1980). In addition to these cognitive factors, the Computer Programmers Aptitude Battery (CPAB) (Palormo, 1974) was included to ascertain its validity in predicting success in academic computer programming and systems analysis courses. Lastly, a number of members in the group felt that creativity was a variable that should be added since systems analysis often requires the generation and evaluation of several alternate designs before an effective solution can be reached. Thus, the Test of Creative Potential (TCP) (Hoepfner and Hemenway, 1973) was used to determine the relative degree of creativity within the sample of subjects.

Regarding affective factors the committee discerned that a high level of persistence is required on the job as well as the ability to reach a high level of technical achievement, both characteristics associated with an individual that displays a task-orientation. Therefore, the task-orientation scale of the Orientation Inventory (ORI) (Bass, 1977) was brought into the study. Furthermore, the instructors voiced a concern regarding anxiety interfering with individual performance in evaluative situations in both the programming and systems analysis academic environments. To ascertain the degree of this anxiety the results of the Test Anxiety Inventory (TAI) (Spielberger, 1980) were added to the data analyzed. The final affective factor included by the group was attitude toward systems design. Several instructors stated that rumors circulating on campus concerning the difficulty and workload of the course may have predisposed certain students to enter the class with a bit of apprehension that may have affected their performance. A Scale To Measure Attitude Toward Any School Subject (SMATSS) (Remmers, 1960) was employed to measure attitude toward systems analysis.

The selected instruments were given, one instrument a week, starting with the second week of the semester. The order of administration was

(1) SMASS, (2) ORI, (3) TAI, (4) GEFT, (5) TCP, (6) WGCTA, and (7) CPAB. By employing this strategy it was hoped that reliability would be enhanced since the maximum testing period was limited to the longest of the instruments, reducing subject fatigue. Furthermore, this situation allowed only one test to be administered per class period which limited the possibility of contamination occurring as a result of interaction between the material contained on the instruments.

Sample

The subjects were 106 students enrolled in one of three sections of Systems Analysis and Design II (DP 242) at St. Louis Community College at Maramec, Kirkwood, Missouri. Enrollees in this class are typically near completion of an Associates in Applied Science in Data

Processing or a Certificate of Proficiency in Data Processing. The composition of the sample was 45 male and 61 female. The average age was 28.5.

Analysis

The raw scores for all the standardized instruments and the final course grades in both Systems Analysis and Design II and COBOL II programming were obtained. In addition, the project grade assigned to the students in Systems II was included. This addition brought to 19 the number of variables utilized in the study. Descriptive statistics using the entire sample as a data base were generated. The intercorrelational matrix computed by the Pearson product-moment procedure containing 19 variables was further analyzed using the common factor model (Nie, Hull, Jenkins, Steinbrenner, and Bent, 1975; Gorsuch, 1974). After eigenvalues for the reduced correlation were calculated, a criteria of an eigenvalue > 1 was set for inclusion. Next the main diagonal of the correlation matrix was replaced with commonality estimates. These estimates were ascertained as a result of the multiple correlations obtained for each variable. Thus the factors were extracted from the reduced correlation matrix and the respective amounts of variance accounted for by these factors were replaced in the matrix as the current estimates of commonality. It took six iterations to reach the model's maximum allowable absolute difference between successive commonality estimates, which was a value less than .001. Five factors were extracted using the SPSS routine for principal component factor analysis. Then each structure was rotated to obtain a normalized varimax solution (Nie, Hull, Jenkins, Steinbrenner and Bent, 1975). Loadings that contained values equal to or exceeding .30 were considered significant.

Two different stepwise regression equations were formulated employing all variables in the study as predictors except the two course final grades which were used as criteria. The first analysis was designed to ascertain which variables could be considered predictors of academic performance in programming course-work while the second computation was devised to determine the potential predictive variables in a formula employing academic performance in systems analysis as the criterion. The probability of F-to-enter (PIN) for both of these equations was set at .1. The results of the step-wise regression analyses identified five potential predictors of academic performance in computer programming and two predictors of academic success in systems design.

One of the charges of the present study was to identify cognitive and affective abilities displayed by the successful and unsuccessful students regarding their achievement in two distinctly different types of data processing courses. To meet this charge two different analyses were undertaken to validate the predictors obtained from the regression analysis. First, the subjects were divided into two groups based upon the final grade they received in COBOL programming. Those students with a B or above were considered the high group (PHI). Subjects that received a C or below were deemed the low group achievement group in regard to programming (PLO). A one-way multivariate analysis of variance (MANOVA) was then performed on the five variables selected by step-wise regression. The second leg of the analysis was similar in structure except the grouping was based upon the final grade the subjects obtained in the Advanced Systems Analysis and Design course. Students who received an A or B in systems were classified high (SHI), while a subject receiving a grade of C or less were characterized as low (SLO). A one-way MANOVA was then applied to the two variables identified by the regression equation to be predictors of achievement in systems design. The MANOVA technique was utilized due to its ability to allow the researcher to view differences among groups of subjects on several variables simultaneously (Jones, 1966). In this case an analysis involving five variables was possible on the programming split, while two variables were analyzed in relation to the system design groups.

RESULTS AND DISCUSSION

The results of the descriptive statistic analysis and intercorrelation matrix are presented in Table 1. Factor analysis using the principal components method was undertaken utilizing the intercorrelation matrix as the data source. On examination of the results the varimax rotation procedure was employed. The varimax rotated factor matrix is included in Table 2.

Outcome for Factor I - General Knowledge

As can be seen from Table 2, eight variables had loadings greater than .30 on Factor I. Four of these items in the form of the subtests inference, deduction, interpretation, and evaluation of arguments came from the WGCTA. In light of the fact that the WGCTA has been found to correlate with general intelligence (Watson and Glaser, 1980) it would seem prudent to have portions of WGCTA included as a portion of this factor. In addition, three of the subtests of CPAB were represented in Factor I. Those measures were verbal meaning, reasoning and number ability. The correlations obtained between these subtests and the Thurstone Test of Mental Alertness (TMA) (Palormo, 1974) would seem to support their addition to the general knowledge factor. Given the acceptance of the supposition that the TMA is actually a test of verbal and mathematical abilities (North, 1972), the correlations (.74 between the TMA and verbal ability, .78 between the TMA and reasoning, .66 between the TMA and number ability) support the inclusion of these abilities in Factor I. The final variable that loaded within the general knowledge factor was the TCP score. Although the TCP loaded higher on Factor II, its inclusion in the factor might be explained by the fact that two of its three subtests use a structure that may be based on one's general knowledge. For example, the writing words exercise requires the subject to generate as many synonyms as he/she can for a given word. Certainly a strong verbal individual would have a broader base from which to proceed than a person with weak verbal skills. The License Plate Words subtest may also relate to verbal ability since the subject is expected to develop words using the letters appearing in the license number and use them in a given sequence.

Outcome for Factor II - Analytic Ability

Five variables loaded within Factor II and in regard to commonality among these variables the ability to disembed material was required. The first variable, the GEFT, measures the degree of field dependence/
independence displayed by a subject. This cognitive style construct has loaded in factor-analytic studies with the analytical factor of the Wechsler intelligence tests (Goodenought and Karp 1961; Karp, 1963). The placement of the GEFT within the analytic factor in this study would be consistent with this prior research. The letter series subtest from the CPAB was the second variable that loaded on Factor II. In this test one series of letters with an embedded pattern is presented to the subject to serve as the criterion. The subject must then analyze the letters and determine the next letter that would occur in the pattern. Therefore, the abilities needed for success in this test would fit into the mold set by the analytic ability factor. Diagramming, also a subtest of CPAB, was the third variable to load on Factor II. Since this test is designed to examine the participants analytical ability to effect a solution to a problem presented in flow chart form in regard to logical sequence of steps, it would seem appropriate for this variable to be included in Factor II. The TCP appeared again as the fourth loading in Factor II. Perhaps it is the test structure that places this variable in Factor II. The License Plate Words subtest, for example, would

require an analysis of letter patterns. In this analytical task, the license number would serve as the embedded portion to a number of surrounding fields; those surrounding fields, of course, would be all the words the subject could devise. Therefore, the presence of the TCP in Factor II can be explained if the assumption regarding the test's structure, which appears to route its placement outside of a single creative factor, is accepted. The last variable to load on Factor II was the course grade in COBOL programming. Being able to write programs from scratch based upon several paragraphs of specifications would undoubtedly require analytical skills. Furthermore, the debugging of these programs after their development would involve a high degree of disembedding skills, since a very minute hidden detail within the program can cause an execution failure.

Outcome for Factor III - Academic Success

Three variables loaded on Factor III; all were either a course grade or a project grade assigned to the subjects by their respective professors in programming and systems design. In one respect this factor might be an indication of the subject's ability to function in an academic environment. However, both courses require a substantial workload either through design projects or programs. Furthermore, there is no set temporal pattern regarding completion of the activities in either course. Both types of activities require persistence on the part of the students to make sure that they complete the assignments and complete them correctly. For example, a program written in COBOL may not execute properly on the first, second, or even the third try. In fact, it may take several more analysis, correction, and resubmission cycles before the desired results are obtained. Therefore, an underlying component of the academic success factor may be persistence.

Outcome for Factor IV - Test Anxiety

Within the fourth factor, loadings occurred on three variables. The two variables that displayed the strongest loadings were the two subtests contained in the TAI. The third variable identified in the anxiety factor was the interpretation subtest from the WGCTA. This same variable loaded at .530 on Factor I, meaning that its loading on Factor IV of .307 might be considered to be of secondary importance to its contribution to the general knowledge factor. Therefore, its appearance, although not expected of a variable generally considered to be related to knowledge, may not be totally inconsistent with relationships observed between TAI subscales and instruments that are dependent on reading comprehension. For example, the correlation presented in the TAI manual between the Nelson-Denny (ND) comprehension subtest and TAI total score for males was -.20 and -.25 for females (Spielberger, 1980).

Outcome for Factor V - Prior Experience

An interesting combination of three variables was obtained from the loadings of Factor V. The highest loading occurred on attitude toward system design, while lesser loadings were recorded for the recognition of assumptions and deduction subtests for the WGCTA. In the case of the deduction appraisal, the loading obtained in Factor V was secondary in magnitude to its loading on the general knowledge factor. However, recognition of assumptions loaded only on Factor V. Although the relationship among deduction, recognition of assumptions and attitude toward systems design cannot be explained with the clarity of some of the other factors obtained in the present study, perhaps there is some relationship among the variables due to the subject's prior experiences. Interestingly, a negative relationship was obtained between recognition of assumptions and attitude toward systems design. It may be that in this study the subject's attitude, if negative or suspicious of new experiences, influenced his/her performance on other variables contained in Factor V. The fact that attitude loaded negatively on the other variables in this factor would tend to support this assertion. However, similar negative relationships have been found in other studies (Defleur, and Westie, 1958). Perhaps this negative relationship is due to a lack of direct relevant experiences. According to Regan and Fazio, 1976, direct experience is a crucial factor in the development of an attitude which is consistent with behavior. In the case of the two variables that loaded only on Factor V, prior direct experience could influence the magnitude of the scores obtained.

However, to prove or disprove this assertion, additional research needs to be undertaken to ascertain whether lack of direct experience in system design related functions is responsible for the negative relationship obtained between recognition of assumptions and attitude toward system design. It could be hypothesized that applying the same measure of attitude to the subjects after completion of the course would yield a more favorable attitude score if, in fact, the course provides direct relevant experiences. Furthermore, if direct experiences related to the development of assumption recognition skills were provided to the subjects, it could be hypothesized that the subject's scores would increase as well. How developing a positive attitude toward system design would influence performance in recognition of assumptions is a question that will have to be answered by further research. Whether a lack of related direct experiences in systems design inhibits one's ability to recognize assumptions would be the critical question to be studied in further research in this area.

Regression Analysis

With the relationship among the various cognitive and affective variables by means of factor analytic methods complete, the next phase of the investigation was carried out using regression analysis on the 19 cognitive and affective variables recorded. Two separate analyses were carried out. The first employed final grade in systems design as the criterion and all but one (final grade in COBOL) of the remaining 18 variables as predictors, while the second equation used final grade in COBOL programming as the criterion and the remainder of the 18 variables minus final grade in systems design as the predictors.

The results of the stepwise regression analysis in which systems design performance was the criterion yielded two predictor which combined to account for 16.8 percent of the variance. Of the two predictors, diagramming accounted for 12.2 percent of the variance while the remaining portion of the 16.8 percent was attributed to recognition of assumptions. In the other analysis, which employed COBOL programming performance as the criterion, five variables were included in the equation before the PIN = 0.100 limit was reached. The variable that made the major contribution regarding variance accounted for was diagramming. This variable, by itself, accounted for 21.0 percent of the variance. In a somewhat surprising development, attitude toward systems design was the second variable selected as a predictor for the equation. This variable, when coupled with diagramming, accounted for 24.4 percent of the variance. The next two variables added to the formula were the two TAI subscales, worry and emotion. Their addition increased the accumulative variance accounted for to 31.5 percent. The final predictor included in the equation was the GEFT score. Its inclusion raised the total accumulative variance explained to 34.0 percent.

The fact that diagramming was picked as the main predictor in each of the equations would tend to indicate that there is some overlap of skills required for success in the two disciplines. Furthermore, it seems logical to expect that the major predictor in each analysis would come from the analytic ability factor. A second variable (GEFT) from this factor appeared in the programming performance analysis reinforcing the importance of factor analytic ability. In all 23.5 percent of the variance was explained by variables that loaded on Factor II in the programming performance prediction equation. Variables from Factor V appeared as predictors in both equations. Recognition of assumptions was selected as a predictor in the formula that employed systems design performance as the criterion. While attitude toward systems design appeared as a predictor of COBOL programming performance in the other analysis.

The other factor represented in the regression analyses was the anxiety factor. Variables that loaded on this factor were included only in the equation employing programming performance as the criterion. In this step-wise regression equation both subscales from the TAI were identified as predictors.

Validation of Predictors (HI-LO) MANOVA

The two potential predictors of academic achievement in systems design having been determined, the answer of whether the abilities identified did indeed differentiate between the successful and unsuccessful systems design student was sought. Table 3 presents the means and standard deviations for the SHI-SLO groups in systems design regarding performance on the predictors diagramming and recognition of assumptions. In terms of magnitude, the SHI group mean exceeded the SLO group mean on both predictors. However, to strengthen the analysis, a MANOVA was performed on both predictors to ascertain if there was any significant difference between the SHI-SLO groups on either predictor. The average F-test with ($F(2,208)=1807.20$ was significant well beyond the .05 level. Furthermore, the univariate F-test with 1 and 104 degrees of freedom revealed a value of 2420.00, $p < .05$ for recognition of assumptions and a magnitude of 1685.54, $p < .05$ for diagramming. Therefore, it would appear that diagramming and recognition of assumptions are not only good predictors of academic success in systems design, but also significantly differentiate between successful and non-successful students.

A similar strategy was used to analyze the ability of the predictors of COBOL programming performance to differentiate between successful and non-successful students. In this analysis the average F-test for the five variables identified as being predictors of success in COBOL programming was ($F(5,520) = 10.14$, $p < .05$. However, in this case there was not the clear difference in the magnitude of the means particularly in the variables: attitude toward systems design and TAI-emotion as is illustrated in Table 4. The results of the univariate F-tests confirmed that significant differences occurred on only three of the five predictors: GEFT score ($F(1,104)$, $p < .05$; TAI-worry ($F(1,104)$, $p < .05$; and diagramming ($F(1,104$, $p < .05$. The other two predictors: TAI-emotion ($F(1,104)$, $p > .05$ and attitude toward systems design ($F(1,104)$ $p > .05$ did not significantly differentiate between the PHI-PLO groups. In regard to diagramming and the GEFT the difference, which would be expected, was in favor of the PHI group. However, in the case of the TAI-worry, the scoring difference was in favor of the PLO group, which would indicate an inverse relationship between TAI-worry and COBOL programming performance.

<u>Summary</u>

In the empirical validation attempts to identify variables related to academic success in both COBOL programming and systems design, the original list of variables was significantly reduced after the MANOVA treatment. The variables found to be predictors of course performance in system design and differentiate between high and low achievers in regard to course grade were diagramming and recognition of assumptions, whereas the predictive variables that differentiated between high and low achievement in the COBOL course were diagramming, TAI-worry, and the GEFT. The results of these findings are mixed in regard to the validation of the CPAB as a predictor of academic achievement in data processing related courses. First, on the positive side the diagramming subtest of the CPAB was the major contributor in the prediction of success in both courses. However, variables from factors not included in the coverage of the CPAB were identified as part of the academic success formula. For example, recognition of assumptions was included from the prior experience factor, a factor which contained no loadings from CPAB variables. Furthermore, TAI-worry was a predictive variable that loaded on the anxiety factor, a second factor that did not include variables from the CPAB subtests. Therefore, based on the results of this study one could conclude that there are one or more important factors missing from the measurement ability of the CPAB in regard to the prediction of academic success in both programming and systems design courses. Whether or not the importance of the missing factors could be substantiated in regard to vocational success is a question for further research which would have to focus upon two questions. First, is there a difference in the ability of successful versus non-successful systems analysts to recognize assumptions? Second, is the anxiety worry level of successful programmers less than that of non-successful programmers? Obtaining the appropriate data sample to determine this information may be difficult, since only the people that complete company training programs in these respective areas are normally appointed to these positions. Therefore, the successful/non-successful split might be undertaken based on a subject's ability to successfully complete company training in programming or systems design.

Lastly, the results of the study suggest that a reduction in administration time, as compared with the total CPAB, could be realized if testing was limited to the variables selected as good differentiators. To measure potential in programming the administration time would drop to 63 minutes (diagramming = 35, TAI-worry = 8, GEFT = 20). Also, the time required for administration of a systems design oriented predictive instrument would be less than the whole CPAB> The time required to administer this instrument would be 45 minutes (diagramming = 35, recognition of assumption = 10). If an instrument was desired that would provide broader coverage, recognition of assumptions could be added to the academic programming prediction instrument, thereby, increasing its predictive potential in the area of systems design. The time required for this testing device would be 73 minutes (diagramming = 35, TAI-worry = 8, GEFT = 20, recognition of assumptions = 10). However, the testing time requirements for this comprehensive evaluation exercise would be in the same range as the total CPAB. This development would mean that this comprehensive evaluation exercise would be in the same range as the total CPAB. This development would mean that reduction of administration time could be realized only on the two specific suggested measurement devices, programming and systems design. Therefore, the advantage of the comprehensive instrument would be that an increase in breath of coverage could be obtained while maintainingan administration time in the seventy minute range.

REFERENCES

Bass, J.M. (1973). Manual for the orientation inventory. Palo Alto: Consulting Psychologists Press.

Beleutz, J.A. (1975). Cognitive style as an indicator of possible success in mastering computer programming. Unpublished doctoral dissertation, University of Maryland.

Burns, W.J. (1973). A study of interaction between aptitude and treatment in the learning of a computer programming. Unpublished doctoral dissertation, University of Maryland.

DeFleur, M.L., & Westie, F.R. (1958). Verbal attitudes and overt acts: An experiment on the salience of attitudes. American Sociological Review, 23, 667-673.

Goodenough, D., & Karp, S.A. (1961). Field dependence and intellectual functioning. Journal of Abnormal and Social Psychology, 63, 241-246.

Gorsuch, R.L. (1974). Factor analysis. Philadelphia: W.B. Saunders.

Hoepfner, R., & Hemenway, J. (1973). Manual: Test of creative potential. Hollywood: Monitor.

Hunt, D., & Randhawa, B.S. (1973). Relationship between and among cognitive variables and achievement in computational science. Journal of educational and Psychological Measurement, 33, 921-928.

Irons, D.M. (1982). Predicting programming performance in novice programmers by measures of cognitive abilities. Unpublished doctoral dissertation, Texas Christian University.

Jones, L.B. (1966). Analysis of variance in its multivariate developments. In R.B. Cattell (Ed.), Handbook of multivariate experimental psychology. Chicago: Rand McNally.

Karp, S.A. (1963). Field dependance and overcoming embeddedness. Journal of Consulting Psychology, 27, 294-302.

McLaughlin, B. (1981). An experimental comparison of discovery and didactic computerized instructional strategies in the learning of computer programming. Unpublished doctoral dissertation, The Catholic University of America.

Nie, N.H., Hull, C.H., Jenkins, J.G., Steinbrenner, K., & Bent, D.H. (1975). Statistical package for the social sciences. (2nd

Ed.). New York: McGraw-Hill Book Company.

North, R.D. (1972). Review of: Thurstone test of mental alertness. In O.K. Buros (Ed.), The seventh mental measurements yearbook (pp.716-718). Highland Park, New Jersey: Gryphon Press.

Palormo, J.M. (1974). Computer programmers aptitude battery: Examiners _ manual. Chicago: Science Research Associates.

Regan, D.T., & Fazio, R. (1977). On the consistency between attitudes and behavior: Look to the method of attitude formation. Journal of _ Experimental Social Psychology, 13, 28-45.

Remmers, H.H. (1960). Manual for the purdue master attitude scales. West LaFayette, Indiana: University Book Store.

Spielberger, C.D. (1980). Preliminary professional manual for the test anxiety inventory. Palo Alto: Consulting Psychologists Press, Inc.

Watson, G., & Glaser, E.M. (1980). Watson-Glaser critical thinking appraisal manual.

Williams, P.L. (1976). Structured programming as an aid in learning FORTRAN programming, useful factors for predicting success in a FORTRAN programming course, and the interaction involved. Unpublished doctoral dissertation, Iowa State University.

Witkin, H.A., Oltman, P.K., Raskin, E., & Karp, S.A. (1971). A manual for the embedded figures tests. Palo Alto: Consulting psychologists Press, Inc.

Table 1

Means, Standard Deviations, and Intercorrelation Matrix Among 19 Variables

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
GEFT	1.00	.04	-.22	-.22	.24	.23	.31	.25	.23	.31	.30	.26	.18	.44	.21	.00	.17	-.19	.29
ORI-Task	.04	1.00	-.16	-.04	.10	.04	.15	.14	.22	.23	.18	.13	.15	.18	.09	.03	.14	.00	.19
TAI-Worry	-.22	-.16	1.00	.76	-.40	-.30	-.33	-.46	-.31	-.41	-.30	-.29	-.22	-.38	-.33	.02	-.19	.14	-.33
TAI-Emotion	-.22	-.04	.76	1.00	-.29	-.11	-.20	-.32	-.17	-.31	-.18	-.11	-.11	-.17	-.15	.15	.02	.09	-.09
WGCTA-Inference	.24	.10	-.40	-.29	1.00	.31	.47	.45	.38	.49	.51	.28	.17	.34	.28	.01	.21	-.03	.24
WGCTA Recognition of Assumptions	.23	.04	-.30	-.11	.31	1.00	.36	.32	.28	.29	.33	.19	.00	.26	.15	.13	.29	-.14	.22
WGCTA-Deduction	.31	.15	-.33	-.20	.47	.36	1.00	.36	.48	.46	.41	.20	.35	.34	.27	.02	.21	-.21	.28
WGCTA-Interpretation	.25	.14	-.46	-.32	.45	.32	.36	1.00	.31	.53	.44	.21	.23	.30	.37	-.02	.14	-.16	.12
WGCTA-Evaluation of Arguments	.23	.22	-.31	-.17	.38	.28	.48	.31	1.00	.40	.37	.31	.26	.34	.25	.02	.13	-.13	.20
CPAB-Verbal Meaning	.31	.23	-.41	-.31	.49	.29	.46	.53	.40	1.00	.53	.19	.40	.28	.43	.10	.24	-.02	.19
CPAB-Reasoning	.30	.18	-.30	-.18	.51	.33	.41	.44	.37	.53	1.00	.45	.54	.42	.29	.12	.19	-.09	.17
CPAB-Letter Series	.26	.13	-.29	-.11	.28	.19	.20	.21	.31	.19	.45	1.00	.33	.55	.46	.04	.23	-.11	.34
CPAB-Number Ability	.18	.15	-.22	-.11	.17	.00	.35	.23	.26	.40	.54	.33	1.00	.24	.26	.11	.21	.04	.19
CPAB-Diagramming	.44	.18	-.38	-.17	.34	.26	.34	.30	.34	.28	.42	.55	.24	1.00	.38	.19	.35	-.07	.45
TCP	.21	.09	-.33	-.15	.28	.15	.27	.37	.25	.43	.29	.46	.26	.38	1.00	.00	.28	.11	.35
System Design Project Grade	.00	.03	.02	.15	.01	.13	.02	-.02	.02	.10	.12	.04	.11	.19	.00	1.00	.71	-.02	.28
Final Grade Systems Design	.17	.14	-.19	.02	.21	.29	.21	.14	.13	.24	.19	.23	.21	.35	.28	.71	1.00	.06	.63
Attitude Toward Systems Design	-.19	.00	.14	.09	-.03	-.14	-.21	-.16	-.13	-.02	-.09	-.11	.04	-.07	.11	-.02	.06	1.00	.15
Final Grade COBOL Programming	.29	.19	-.33	-.09	.24	.22	.28	.12	.20	.19	.17	.34	.19	.45	.35	.28	.63	.15	1.00
MEAN	14.1	32.9	13.5	15.3	9.4	12.9	11.3	12.8	12.2	16.6	9.5	13.5	12.5	24.3	63.7	153.1	2.6	7.8	2.9
dard Deviation	4.3	6.1	5.0	5.3	2.7	2.8	2.4	2.3	2.4	6.1	4.3	4.4	5.0	6.5	19.2	39.5	1.0	0.8	1.1

Table 2

Varimax Rotated Factor Solution
For 19 Variables*

Variables	I	II	III	IV	V	Estimated Commonality: Principal Components	Estimated Commonality: Interactive
T		.334				.34	.26
-Task						.14	.07
-Worry				-.839		.74	.86
-Emotion				-.795		.66	.68
TA-Inference	.525					.48	.42
TA-Recognition of Assumptions					.420	.36	.32
TA-Deduction	.529				.363	.48	.46
TA-Interpretation	.530			.307		.44	.43
TA-Evaluation of Arguments	.452					.34	.34
B-Verbal Meaning	.781					.57	.68
B-Reasoning	.693					.61	.59
B-Letter Series		.710				.50	.57
B-Number Ability	.542					.47	.37
B-Diagramming		.644				.52	.61
	.387	.435				.45	.40
tem Design roject Grade			.717			.63	.53
al Grade Systems Design			.951			.75	.97
itude Toward ystems Design					-.511	.27	.26
al Grade obol Programming		.482	.520			.58	.55

ndings Less than .30 have been omitted

Table 3

Means and Standard Deviations for the SHI and SLO System Design Groups

Variable	Mean SHI(N=65)	Mean SLO(N=41)	SD SHI	SD SLO
Diagramming	26.2	21.2	5.7	6.5
Recognition of Assumptions	13.5	11.9	2.4	3.0

Table 4

Means and Standard Deviations for the PHI and PLO COBOL Programming Groups

Variable	Mean PHI(N=79)	Mean PLO(N=27)	SD PHI	SD PLO
Diagramming	25.7	19.9	5.7	6.8
Attitude Toward System Design	7.9	7.7	0.7	1.0
TAI - Worry	12.8	15.8	4.4	6.0
TAI - Emotion	15.1	15.7	5.0	6.3
GEFT	14.9	11.7	3.7	4.9