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Since the need for good programers exists and will increase, their identification before training is desirable. Until now only single tests of potential ability have been evaluated. In this study several tests used in various combinations were evaluated as test batteries. The IBM Aptitude Test for Programmer Personnel (ATPP) and the Strong Vocational Interest Blank (SVIB) were administered to 68 students enrolled in an introductory computer science course at Michigan State University. Grade point average (GPA) and College Qualification Test (CQT) scores for participants were available from college records. All test scores correlated significantly with course grade (p .05). GPA was found to be the best single predictor of success. Among total test scores, general scholastic aptitude (the CQT) predicted achievement as well as specialized aptitude (the ATPP). However, the best results were found to be obtainable with a judicious choice of subtests emphasizing numerical and spatial reasoning (ATPP Part III, CQT Numerical). An "interest" variable as assessed by the SVIB appeared to identify a dimension discrete from aptitude that was significantly related to course achievement. The results were taken to indicate that instruments presently available can be used effectively to predict achievement in computer programing. (SS/MF)

# PREDICTING PERFORMANCE IN A COMPUTER PROGRAMMING COURSE

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# PREDICTING PERFORMANCE IN A COMPUTER PROGRAMMING COURSE

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Computer programming is one of the fastest growing of the new technical professions. Large numbers of programmers are needed immediately, and it is predicted (Seiler, 1965) that by 1970 there will be a half million new jobs in electronic data processing. Computers are more and more being forced to perform well below their potential for lack of programmers.

Automatic data processing has had a significant impact on private business schools; most of the larger ones now have computer-training programs for operators and technicians (Fulton, in press). Too often, however, specialized schools accept students with scant aptitude for computer training; and unqualified graduates ultimately heighten rather than alleviate the critical shortage of personnel in this area. Thus the need is apparent for tests capable of identifying potentially adequate computer programmers.

Katz (1962) administered several tests from the Army Classification Battery to 190 trainees in the Army's Automatic Data Processing Programming course. He used these test results in an attempt to reduce the wasted training time and costs associated with the prevailing high attrition rate. Test scores were correlated with final grade in the course. A combination of verbal and arithmetic reasoning tests from the army battery yielded a correlation with grade of .61; the IBM Programmers Aptitude Test correlation with grade was .67; the multiple correlation of these tests with grade was .68.

Hollenbeck and McNamara (1965) rated the programming ability of 27 programmer trainees at the end of a 26 week training program. These ratings were then correlated with scores on the Computer Usage Company Programmer Aptitude Test, a computer-based apparatus test (rho = .30), and IBM's Data Processing Aptitude Test (rho = .49). Seiler (1965) obtained correlations ranging from .35 to .62 between supervisors' ratings of workers in electronic data processing jobs and combinations of three or more subtests from the GATB. Biamonte (1965) administered the Wonderlic Personnel Test plus three attitude tests* ("authoritarianism," "conservatism," and "dogmatism") to 201 students in computer programming courses. Correlation of scores on the Wonderlic with course grade was .52, attitude scores had low negative correlations with grade, and the multiple correlation of all four tests with grade was .53. Thus in this study measures of attitudes contributed very little to the prediction of performance in a programming course.

Currently, the literature reveals no test <u>batteries</u> designed explicity for the purpose of identifying potentially good computer programmers. Most previous research has been confined to the use of a single test, usually of general intelligence. The purpose of the present study was to perform some preliminary research for the development of such a battery, comparing the predictive effectiveness of various existing tests singly and in combinations. A second purpose of this study was to examine the validity of two existing instruments for predicting success in programming: the new Computer Programmer key of the Strong Vocational Interest Blank (Campbell, 1966) and the Aptitude Test for Programmer Personnel (IBM, 1964).

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*California F-Scale of Authoritarianism, McClosky's Conservatism Scale, and Rokeach's Dogmatism Scale.

Method

The subjects were 68 students 58 men and 10 women, both undergraduate and graduate, enrolled in Computer Science 110 at Michigan State University. This ten-week course is an introduction to elementary computer programming using Fortran vocabulary. Final grade in the course was the criterion of programming performance. This grade was based entirely on the total score amassed by the student on 4 programs written as homework assignments, 3 hourly tests based on lectures and assigned readings, and a 2-part final consisting of 1) questions on theory and facts and 2) problems involving the actual writing of programs. All test questions were constructed by the instructor and were in objective form.

Two predictor variables were the IBM Aptitude Test for Programmer Personnel (ATPP)* and the Strong Vocational Interest Blank (SVIB) which were given to the students in two 1-hour sessions at the beginning of the course. Other predictors were scores on the College Qualification Test (CQT), which the students had taken upon admission to Michigan State University, and grade point averages (GPA's) attained in all previous courses at Michigan State University.

The ATPP is a one hour paper and pencil test of reasoning ability designed by IBM to aid in the selection of computer programmers. It consists of 3 subtests: Part I, a letter series test; Part II, a figure series test; and Part III, an arithmetical reasoning test. The manual reports a test-retest reliability from a sample of 144 college students of .88 for the total test (IBM, 1964).

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The authors express their appreciation to IBM for making these tests available.

The CQT is a general scholastic aptitude test for college applicants which yields a total and 3 part scores: verbal ability, numerical reasoning, and general information. Two scales from the SVIB were examined, the new Computer Programmer Scale and the Academic Achievement Scale.

## Results

The simple correlations of the independent variables (ATPP total and Parts I, II, and III; CQT total and Verbal, Numerical, and Information; the Programmer and Academic Achievement Scales of the SVIB; and GPA) with the dependent variable (final course grade) are reported in Table I below.

Table I

Simple Correlations of the Predictors with Course Grade

| | | | |
|---|---|---|---|
| GPA | .68 | ATPP Part I | .30 |
| CQT Total | .49 | ATPP Part II | .43 |
| CQT Verbal | .37 | ATPP Part III | .48 |
| CQT Numerical | .53 | SVIB Programmer | .33 |
| CQT Information | .32 | SVIB Academic Ach. | .33 |
| ATPP Total | .51 | | |

All independent variables were significantly correlated with course grade at the .05 level. The best single predictor was GPA followed by the numerical subtest of the CQT, ATPP and CQT total scores, and Part III (numerical) of the ATPP. Table II contains the intercorrelations of the predictor variables.

Table II

Intercorrelations of Predictor Variables

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ATPP Total | 1 | -- | | | | | | | | | | |
| ATPP Part I | 2 | .85 | -- | | | | | | | | | |
| ATPP Part II | 3 | .66 | .42 | -- | | | | | | | | |
| ATPP Part III | 4 | .79 | .47 | .29 | -- | | | | | | | |
| CQT Verbal | 5 | .43 | .33 | .15 | .47 | -- | | | | | | |
| CQT Information | 6 | .45 | .36 | .20 | .45 | .56 | -- | | | | | |
| CQT Numerical | 7 | .50 | .29 | .26 | .59 | .33 | .41 | -- | | | | |
| CQT Total | 8 | .57 | .41 | .24 | .61 | .88 | .81 | .64 | -- | | | |
| GPA | 9 | .44 | .23 | .15 | .57 | .50 | .50 | .51 | .62 | -- | | |
| SVIB Programmer | 10 | .02 | .02 | .05 | .00 | -.06 | .06 | .24 | .06 | .04 | -- | |
| SVIB Aca. Ach. | 11 | .14 | .17 | .07 | .06 | .37 | .36 | .23 | .42 | .28 | .13 | -- |
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |

A step-wise addition multiple regression analysis was computed using all independent variables to determine the best combination for predicting course grade. The best two-score combination proved to be GPA and Part II (Figure Series) of the ATPP (R = .76); the best three-score combination was obtained by adding the Computer Programmer Scale of the SVIB (R = .81). Further additions did not significantly improve the multiple correlation.

Because GPA accounted for such a large portion of the variance in course grade (r = .68) another multiple regression analysis was computed omitting GPA as an independent variable. In this case the best two-score combination was CQT numerical and Part II of the ATPP (R = .61); addition of the Computer Programmer Scale of the SVIB raised the multiple correlation to .65; addition of CQT verbal gave an R of .68. Further additions did not significantly improve the multiple correlation. Table III summarizes the multiple regression analysis.

Table III

Multiple Correlations of the Predictors with Course Grade

| | R |
|---|---|
| Best combinations | |
| GPA and ATPP Part II | .76 |
| GPA, ATPP Part II, and SVIB Computer Programmer | .81 |
| Best combinations excluding GPA | |
| CQT Numerical and ATPP Part II | .61 |
| CQT Numerical, ATPP Part II, and SVIB Computer Programmer | .65 |
| CQT Numerical, ATPP Part II, SVIB Computer Programmer, and CQT Verbal | .68 |

## Discussion

Tests are probably used more often in the selection of candidates for computer programmer training than in the hiring of computer programmers. Thus, despite its limitations, the use in this study of final grade in a computer programming course as the criterion of programming success seems justified. In fact, the ATPP is designed specifically to select individuals who will be successful in programmer training courses.

The results suggest that the measures presently available do a pretty fair job of predicting grades. As is typical, the best single predictor of academic success was past academic success, i.e., GPA. Those wishing to select applicants for programmer training, however, will not always have grade point averages available. In this case, the results excluding GPA as an independent variable would be of most interest.

The ATPP was not appreciably better in predicting programming aptitude than the CQT, a general scholastic aptitude test. Indeed, with the exception of GPA, the highest single correlation with course grade was obtained with the Numerical subtest of the CQT. Since general scholastic test results are commonly available ~~it~~ them would be more efficient to use these data rather than to replace it with ATPP data. However, examination of the multiple regression analysis suggests that subtest combinations can predict programming success better than any one total test. Numerical reasoning (CQT Numerical) and spatial reasoning (ATPP Part II--figure series) appear to be the most important cognitive aspects for success in computer programming.

Of special interest is the fact that, while the simple correlation of the SVIB Computer Programmer scale with grade was not particularly high (r = .33), this measure did significantly improve the prediction obtained from cognitive measures alone. As can be seen from Table II, the SVIB-CP scale was measuring something different from the other predictor variables. This unique "something" (call it interest) does significantly help to predict computer science course grades.

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