PREDICTING PROGRAMMER PERFORMANCE

new study report on factors affecting p. i. preparation

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The continuing high interest in programming as a key part of the "training revolution" is evident in the constant discussion of the faults of the movement versus the promise of a better technology of learning. To illustrate the contrast, many educators or those interested in instructional systems feel that the teaching machine is education's Edsel, but that the concept of programmed instruction is mature and an excellent analysis and design process.

This interest in the programmer as the key link in the system has been a vital concern. From the early days of the movement there have been studies seeking to determine what personality variables or special educational backgrounds were useful in predicting programmer performance. This search technique followed basic personnel strategies using questionnaires and job analysis instruments. The background studies which follow will provide a useful basis for viewing the pattern of research.

PRIOR STUDIES

As early as 1959 there was some thought about what characteristics the programmer should have. Smith[1] speculated that the programmer should have something of an introvert personality as well as an analytical, creative nature.

Hughes[2] put forth a set of characteristics which included being a subject-matter expert, intelligent, analytical, flexible, and highly motivated.

At the same time Hughes was writing, mail surveys were being conducted by Polin, Morse, and Zenger[3] regarding the selection of programmers for industrial and business organizations. The 1962 experience was limited and of the 120 respondents, only 49 reported that they felt they had significant experience in the process of supervising programmers to offer critical evaluations. The general results of that survey centered around educational backgrounds (mostly English, psychology, education and research-orientations) and around certain ability characteristics (job ability, technical background, and writing skill).

Lysaught[4] published an extended piece of research at the University of Rochester seeking to contrast the high and low performers who had received instruction at their School of Education. This study was in part a testing of earlier statements as well as the introduction of new factors. Regarding the earlier research efforts, Lysaught reported a considerable difference in results. This was to be expected since Morse *et al.*, were surveying business and industrial managers while the Lysaught study went primarily to a teacher group. Focusing on the outcomes of the Lysaught work, it was reported that the high and low groups were significantly different in regard to intelligence quotient, critical thinking ability scores and theoretical value scores.

Up to this point, the studies were mostly post-hoc in trying to determine the characteristics of a successful programmer. The focus of this study was to develop an instrument for predicting programmer performance while in training and in field operations.

METHOD

The design of the study was a two-part comparison. In phase one the pre- and post-tests scores were derived from a written performance instrument. The instrument required the trainee to meet the following tasks:

A. Analysis of initial learning state of the learner population;

B. Analysis of the instructional material to determine what concepts had to be learned; and

C. The construction of a draft sequence to meet the instructional objective (which was supplied by way of test items given to the trainee).

In phase two, these same post-test scores were compared with the reported use of programming. A one-page mail questionnaire was used which requested the following data:

A. State of completion (what point between initial analysis and final revision);

B. Number of projects undertaken;
C. Percentage of time allocated to programming;
D. Nature of the problems encountered on the project; and
E. Personal comments

Figure 1 illustrates the two-stage project.

A natural research design was used and no attempt was made to alter any of the other variables which might influence performance. The questionnaire used in phase two of the data collection was mailed to each participant one month after the completion of the one-week training course.

Each of the 111 persons taking part in the study was a participant at the Center for Programmed Learning for Business' one-week workshop. Cooperation was excellent and the instruments were administered and completed without incident. The following tables present the distribution of people attending the course.

TABLE I
PARTICIPANT DISTRIBUTION BY JOB CATEGORY

Job Category	Percentage*	Number
Training & Development	52%	59
Supervisor	23	24
Personnel	3	3
Engineering	6	6
Education	4	5
Sales	7	8
Other	5	6
	100%	111

*Some rounding to use whole numbers

This job category distribution remained quite stable during the four months of data collection. This same stability was true of the percentage of male and female participants shown in Table II.

RESULTS AND DISCUSSION

(1) **Statistical Analysis.** The results were quite positive, both in phase one and in phase two. Correlations using the chi-square analysis were at or beyond the 0.01 level. For phase one the average pre-test score was 3.43 (range of 0 to 10 and standard deviation of 2.26) and the post-test score average was 6.73 (range of 0 to 10 and standard deviation of 2.51). The chi-square value was 14.07 which is significant beyond the 0.01 level. Thus phase one presented a firm foundation for the use of the post-test in phase two of the study.

An analysis of the follow-up respondents indicated that their profile was very close to the original sample and with a 59% response rate the follow-up was deemed to be representative of the initial total sample. The participants reported their implementation efforts on a ratio scale of achievement versus percentage of time allocated to programming. The data received had the following characteristics: average ratio of 0.11 (range of 0.0 to 1.0 and a standard deviation of 0.16). The 65 responses were coded by the researcher and compared to the post-test using the chi-square analysis. The resulting chi-square value was 10.55 which was significant beyond the 0.01 level.

(2) **Interpretations.** The highly significant results regarding the pre- and post-tests were most encouraging. The earlier studies cited were attempting to find relationships or characteristics which would be useful in the selection and prediction of programmer performance. This study was different in that an attempt was made to design a pencil and paper performance instrument which would evaluate the individual's instructional abilities without regard to any pre-selection model. The benefit to the training or personnel director is that the individual who shows a weakness in this area will know the fact and that corrective steps can then be taken to provide special help. (In this study there was, of course, no special help given to the low achievers on the pre-test as that would have contaminated the post-test results.) In general, the well known pattern of prior achievement predicting future achievement seems to apply to the skill of programmed learning as well as other intellectual tasks.

Figure 1. Research Design

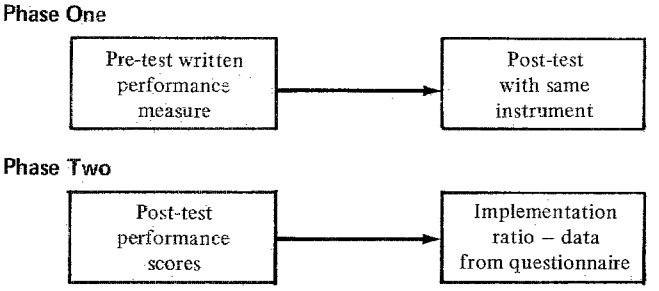

TABLE II
PARTICIPANT DISTRIBUTION BY SEX

	Month 1	2	3	4	Avg. Totals
Male	20 (67%)	19 (73%)	19 (73%)	18 (62%)	76 (68%)
Female	10 (33%)	7 (27%)	7 (27%)	11 (38%)	35 (32%)
n=	30	26	26	29	111 (100%)

The analysis and interpretation of the phase two results are also positive and useful. Phase two of the study asked the research question about the need for technical skill and the amount of implementation success the individual participant reported. A tentative analysis of this management development effort suggested that technical skill would be a prerequisite to future action. The data clearly supports this hypothesis. For the operating manager the message is then translated into the need for insuring that the individual programmer-to-be receives competent instruction geared to producing a high level of technical ability.

SUMMARY AND CONCLUSION

The research investigated the selection and training of programmed learning specialists. In reviewing the state of the art it was noted that a great number of studies have been conducted to determine what personality factors or educational background might predict successful performance. No definite answer exists for the personality question at this time. In contrast to a personality-type analysis, this research focused on the development of measures of programmer performance both during a training course and later in the implementation stages. Before the trainee begins this formal training, performance can be measured and his success in the training course accurately predicted. By taking the post-score achieved during that training, a second estimate of implementation potential can be made with a high degree of confidence.

Many members of the programming community hold their own personal views as to what traits or background characteristics are most useful in acting as a successful educational innovator. Many of these views are not stated in the literature because of a lack of empirical evidence. One trend in this area seemed clear, however. There is a growing view that although the successful programmer must have technical and personal skills, these skills are subordinate to the structure of the organization and the nature of the organization's commitment to the project's goal.

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