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MOTIVATION NORMS FOR SOFTWARE ENGINEERS VERSUS THOSE FOR PROGRAMMER ANALYSTS

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ABSTRACT

This paper reports the results of a national survey of members of ACM's SIGSOFT (Special Interest Group for Software Engineering) on key factors for motivation. The results are compared to the national norms for business application programmer/analysts, established through the same survey methodology.

INTRODUCTION

The decline in U.S. productivity is causing leaders in industry and government to rely less on previous technological approaches. They are concentrating on new technology in hopes of regaining an international competitive edge. The computer is integral to this new American thrust.

With increased demand for their services, managers of computer departments are also seeking ways to improve productivity. While improvement in hardware/software techniques is essential to enhancing productivity, so is improvement in employee motivation. But what are the key factors for motivation? What, specifically, can managers do to enhance their department's motivational environment?

We instituted a research program in 1977 to provide answers to that question. A great deal of research had been conducted for other fields, but little had been done in the computer field. Our objective was to gather data on employee perceptions on motivation, utilizing rigorous research methodology. Through such an approach we could assure managers in the computer field of the reliability of our procedures and the validity of our findings. We also sought to develop a procedure for motivation that would have validity in the computer field. Again, we used systematic methodology in the testing and application of this procedure.

Since 1977 we have developed motivational norms for 17 job categories in the computer field. Among those job categories are: scientific programmers, business application programmers, business system analysts, database designers, network designers and system programmers. However, we were not able to develop norms for software engineers through our normal survey methodology. The problem in that job category has been inconsistency in job titles and job content in many companies. A first cut survey for software engineers showed that some companies did not use that title for software engineering types of work while others called all programmers software engineers, regardless of their job content or qualifications. In the latter companies, new programmers were labeled junior SEs and experienced programmers were called senior SEs, with several intermediate levels.

Our normal procedure for deriving motivational norms was not appropriate for this situation. Normally we select firms from representative industry categories and geographic locations to survey in order to develop a national norm for a job category. We decided instead to develop national norms for software engineers by sampling members of ACM's Special Interest Group on Software Engineering (SIGSOFT). However, since ACM has no qualifying requirements for members to join this SIG, it is possible for persons without SE qualifications to become members. Nevertheless, our survey questionnaire elicits information on work content, so we are able to differentiate persons performing software engineering from other job categories. The questionnaire also elicits demographic data to enable us to evaluate qualifications.

WHAT DISTINGUISHES SOFTWARE ENGINEERING

Characteristics of a software engineer were identified by Wasserman and Freeman (1978) and Boehm (1976). A concise description of the factors that distinguish this job from others in the computer field was provided by Fairly (1985).

> "Software Engineering differs from traditional computer programming in that engineering-like techniques are used to specify, design, implement, validate, and maintain software products within the time and budget constraints established for the project. In addition, software engineering is concerned with managerial issues that lie outside the domain of traditional programming. On small projects, perhaps involving one or two programmers for one or two months, the issues of concern are primarily technical in nature. On projects involving more programmers and longer time durations, management control is required to coordinate the technical activities."

At this time, knowledge of the special tools and techniques of software engineering is provided primarily through graduate level programs. Some companies have developed training programs to provide this knowledge to experienced personnel. Acquisition of this knowledge requires a mathematics and science background equivalent to that provided by undergraduate degree programs in the engineering and scientific disciplines.

Persons with such an educational background, and who are engaged in activities such as those listed in the Fairley definition, were the ones selected out of the SIGSOFT survey for developing the national motivation norms for software engineers.

SURVEY METHODOLOGY

The Job Diagnostic Survey for Data Processing (JDS/DP) was mailed to a ten percent sample of the more than 6,000 members of SIGSOFT. The survey instrument will be discussed below. It was authorized by the ACM Executive Committee. Considerable care was taken to ensure representativenesss in regard to sex, age, education, and years of company experience. In addition, industry representation was stressed in regard to company size, geographic location, and type of business. No more than two persons were selected from any one organization to ensure a wide cross-section of response.

Survey response was exceptionally good. A 54% response rate resulted, more than 2 1/2 times the norm for targeted mailed surveys. After eliminating responses from persons not performing software engineering work, the number of usable surveys totaled 285, reducing the response rate to 47% for data used in the final analysis.

The profile of participants will be provided later in the paper. However, the survey instrument needs explanation at this point. The Job Diagnostic Survey for Data Processing (JDS/DP) was the same instrument used by my co-researcher, Robert Zawacki (a behavioral scientist), and myself (a computer scientist) in our surveys to develop national norms for the computer field. We expanded the generic JDS developed by J. Richard Hackman and Greg R. Oldham to include computer related questions. They substantiated the reliability of the JDS in studies of more than 6,000 subjects (Hackman and Oldham, 1975). We revalidated the JDS/DP for the computer field (Couger and Zawacki, 1980) and now have a national database of over 8,000 persons in 17 different jobs in the computer field.

Key Motivating Factors

Jac Fitz-enz's study of 1,500 persons in software development jobs identified broad factors for motivation for these personnel (Fitz-enz, 1978). He used the survey instrument developed by Frederick Herzberg to study motivation of personnel in other fields (Herzberg, 1959). The Fitz-enz results were not dissimilar to Herzberg's. For example, salary is not a primary motivator. Of the factors studied, it ranked 6th place in importance in the Herzberg studies of other occupations and 10th in the Fitz-enz study of software personnel. Job security ranked 16th in the Herzberg studies and 13th in the Fitz-enz study.

Both Herzberg and Fitz-enz found that the most important motivators are related directly to the work being performed -- not to compensation or working conditions. That is the answer to the first questions posed in the introduction of this paper.

Our research has concentrated on the second questions, "What are the work characteristics that managers in the computer field can use to enhance the motivational environment? The remainder of this paper will be devoted to that subject.

The Herzberg studies did not break the work itself into components. A subsequent research project (Turner and Lawrence, 1965) examined more than 30 job variables to isolate those variables most sensitive to motivation. Based on these results, Hackman and Lawler developed a model of motivation around the five variables most influential on motivation (Hackman and Lawler, 1971). They labeled these variables "core job dimensions."

Understanding each core job dimension is essential to improving a company's motivational environment, so each is defined below:

1. **Skill Variety:** The degree to which a job requires a variety of different activities in carrying out the work, which involve the use of a number of different skills and talents of the employee.

2. **Task Identity:** The degree to which the job requires the completion of a "whole" and identifiable piece of work -- i.e., doing a job from beginning to end with a visible outcome.

3. **Task Significance:** The degree to which the job has a substantial impact on the organization -- either in the computer department or in other departments of the company.

4. **Autonomy:** The degree to which the job provides substantial freedom, independence, and discretion to the employees in scheduling their work and in determining the procedures to be used in carrying it out.

5. **Feedback from the Job Itself:** The degree to which carrying out the work activities required by the job results in the employee obtaining information about the effectiveness of his or her performance.

The JDS/DP elicits employee perceptions about the degree to which the five core job dimensions are provided in their jobs, as well as perceptions on 18 other variables in the work setting. Before examining the results of the SIGSOFT survey, it is necessary to identify what delineates software engineering from the other 17 job types for which national norms had been established.

SIGSOFT Ratings for Core Job Dimensions

Table 1 provides the responses of the SIGSOFT survey on the core job dimensions, compared to the national norms for business application programmer/analysts. The SIGSOFT means not only exceed five on the scale of seven, but are significantly higher than the P/A norms in three of the five categories. Significance is at the $p < .001$ level. Standard deviation is also significantly lower than that of P/As on two job dimensions: skill variety and autonomy.

However, the results prompt the question, "Are the jobs of software engineers too rich?" The behavioralists have shown that demotivation can occur if such a situation exists. The richness of a job is based on the degree to which the five core job dimensions are in existence. Our research has shown that scores above five on the scale of seven indicate jobs that are rich, that is, have proper motivating capacity. Figure 1 depicts the motivation model for computer per-

Core Job Dimensions	P/A National Norms	SIGSOFT Survey	Significant Differences
Skill Variety	5.45	5.91	+
Task Identity	5.30	5.69	+
Task Significance	5.70	5.64	0
Autonomy	5.50	5.99	+
Feedback From Job	5.15	5.09	0

Scale of 7 where 7 is high

Table 1. SIGSOFT Survey Responses Compared to the National Norms for P/As

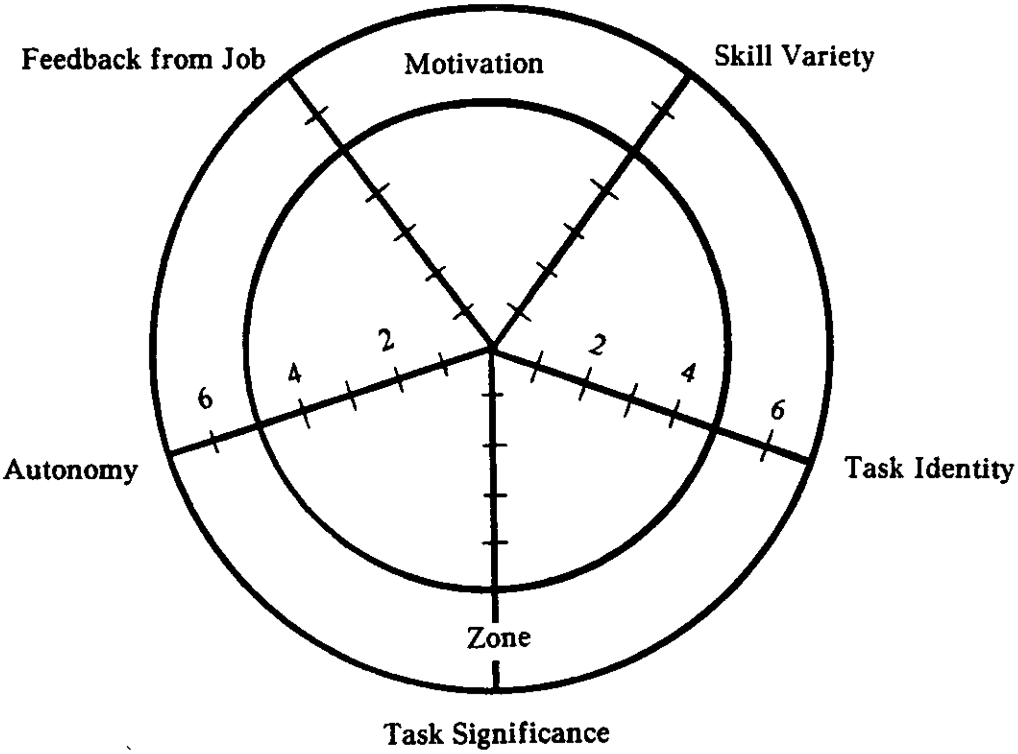


Figure 1. Model of Motivation.

sonnel. The outer ring contains values of five through seven, representing the motivation zone. The inner ring represents the demotivation zone. The summary variable denoting the overall richness of the job is called the job's motivating capacity (JMC). It is obtained by adding the values for the five core job dimensions.

The validity of the JMC approach for representing the potential of the job to motivate incumbents in other occupations was substantiated by Hackman and Oldham (1980). Our research validates its applicability to the computer field (Couger and Zawacki, 1980).

But the JMC alone does not determine whether employees will be properly motivated. JMC must be compared to employee's need for achievement. If the two factors are not equivalent, motivation rarely results.

Matching the Job to the Individual

A shortcoming of the work of Herzberg was his concentration on enrichment of all jobs regardless of the needs of the individuals filling the job. McClelland's work (1961) on need for achievement paved the way for the subsequent work by Lawler and Hackman (1971) on matching the individual needs to the job's motivating capacity. They proved that the key to motivation was the match between JMC and individual's growth need strength. GNS is a measure of employees' need for personal accomplishment -- for learning and developing beyond where they are now, for being stimulated and challenged. GNS for computer personnel in our original studies was significantly higher than of any of the 500 jobs studied by Hackman and Oldham. On the other hand, it is not surprising that the highly dynamic computer field attracts and retains people with high GNS. If it were not for their high GNS, people in this field would be continuously frustrated at the rapid turnover of knowledge in the field.

Fortunately, from a motivational standpoint, the JMC for most computer industry jobs is significantly higher than that of other occupations. A good JMC/GNS match exists in all computer jobs except for computer operators. Although GNS of computer operators is in the upper quartile of all measured occupations, JMC is in the lower quartile. In contrast, the job of scheduler in computer operations has both GNS and MPS in the upper quartile of measured jobs.

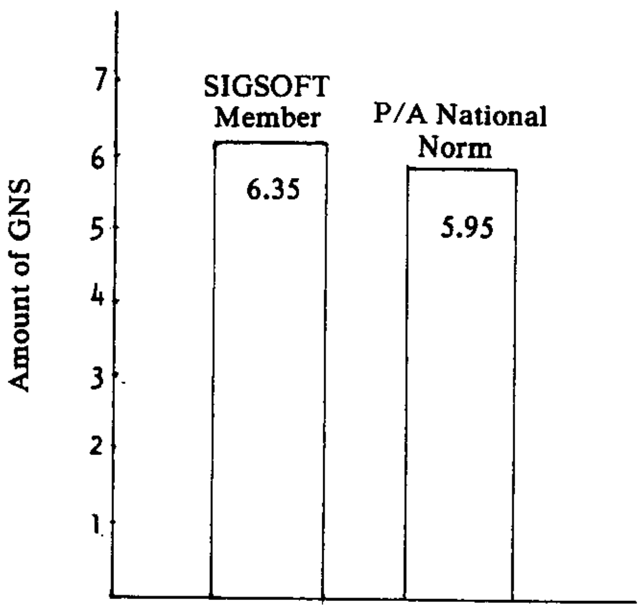


Figure 2. Comparison of Growth Need Strength for Software Engineers vs. Programmer/Analysts.

HYPOTHESIS TESTING

Because of the need to provide survey background it was not feasible until this point in the paper to explain the three hypotheses posed for testing in our research on software engineers:

> **Hypothesis 1:** Norm JMC for software engineers is higher than that of business application programmer/-analysts.

> **Hypothesis 2:** Norm GNS of software engineers is higher than that of business application programmer/-analysts.

> **Hypothesis 3:** A satisfactory match in GNS and JMC exists for the software engineer, ensuring positive work motivation.

The results cited above indicate that the first hypothesis was substantiated; norm JMC for software engineers is significantly higher than that of programmer/analysts. But is the job too rich? How does GNS for the software engineer compare to that of the P/A? Figure 2 provides this comparison. The norm GNS of software engineers (6.35) is significantly higher than the 5.95 norm for P/As. A statistical test of differences shows the two means to be equivalently different, at the $< .001$ level. Therefore, the second hypothesis is also substantiated.

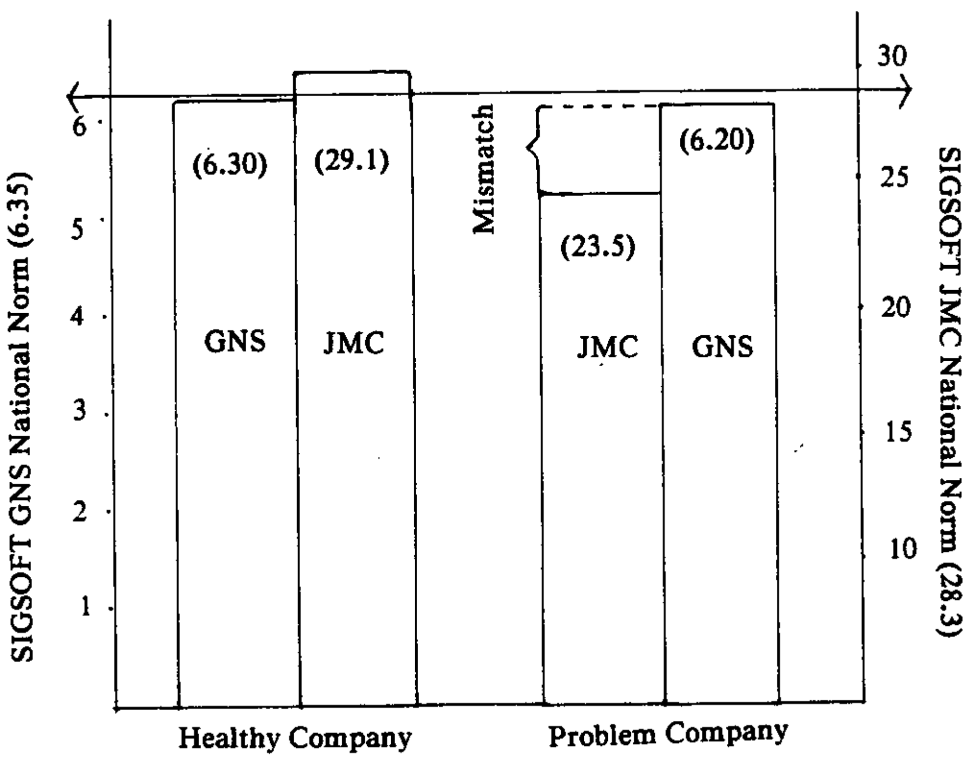
Concerning the third hypothesis, that there is a match of GNS and JMC for software engineers, further discussion is required to find support for this hypothesis.

Although the survey data prove the GNS/JMC match for SEs is significantly higher than that of PAs, the questions of a proper match still exists. Our experience in use of the other norms provides the answer to this question. The P/A norms were developed six years ago. We've had an opportunity to track performance in companies where the norms were established. The only productivity measures common to these companies are budget and schedule compliance. Based on these measures, performance has been satisfactory in companies where the GNS and JMC of P/As are equivalent to the national norms. We've also had opportunity to observe a number of organizations where motivational problems exist and where a GNS/JMC match did not occur.

Despite the recency of our development of software engineering norms, we've also had an opportunity to observe companies in which a mismatch exists for this job type. Figure 3 provides a comparison of SEs in two organizations -- one where GNS and JMC are not significantly different from the national norms. In the other organization, there is a serious mismatch. GNS (6.20) is not significantly different from the norm; but JMC (23.5) is significantly lower than the norm. Productivity figures confirmed the diagnosis -- schedules are rarely met and budget overruns were prevalent in the company with the JMC/GNS mismatch.

Nevertheless, support for hypothesis three can only be provided experientially. Seven years of experience in the observance of GNS/JMC for P/As shows the national norms to represent a satisfactory match. That is, companies we've observed where such a match exists are experiencing satisfactory productivity. Since GNS/JMC for software engineers is equivalently higher, it seems reasonable to assume a match here as well. However, the hypothesis will remain unsubstantiated until further data are collected from individual firms, such as the firms illustrated in Figure 3.

Figure 3. Comparison on GNS/JMC Match.



RESULTS

Improving Motivation

Figure 4 identifies the specific core job dimensions that were deficient in the problem company shown in Figure 3. This Kiviat chart reveals that three of the five core job dimensions were below the motivation zone. Table 2 gives the specific values compared to the SIGSOFT norms. Although the value for autonomy (5.18) was significantly lower than the SIGSOFT norm, it was in the motivating zone (indicating that the need for improvement was much lower than the other three core job dimensions).

However, when the results were isolated by job category, it was clear that the problem was at the lower end of the career path. The match for SE IVs and SE Vs was satisfactory. The mismatches were occurring for entry level SEs through SE IIIs. On each of the three deficient core job dimensions standard deviation was lower than the norms also, indicating the problem as prevalent for the majority of SEs in these three levels.

With this information, management can employ the management-by-exception principle. Instead of a massive project to enhance all jobs, management could concentrate on the problem core job dimensions for SEs below level IV.

Table 2. Comparison of Responses on Core Job Dimensions.

Core Job Dimensions	SIGSOFT Norms	Problem Company	Significant Differences
Skill Variety	5.91	4.85	*
Task Identity	5.69	5.32	
Task Significance	5.64	3.62	*
Autonomy	5.99	5.18	*
Feedback from Job	5.09	4.35	*

Scale of 7

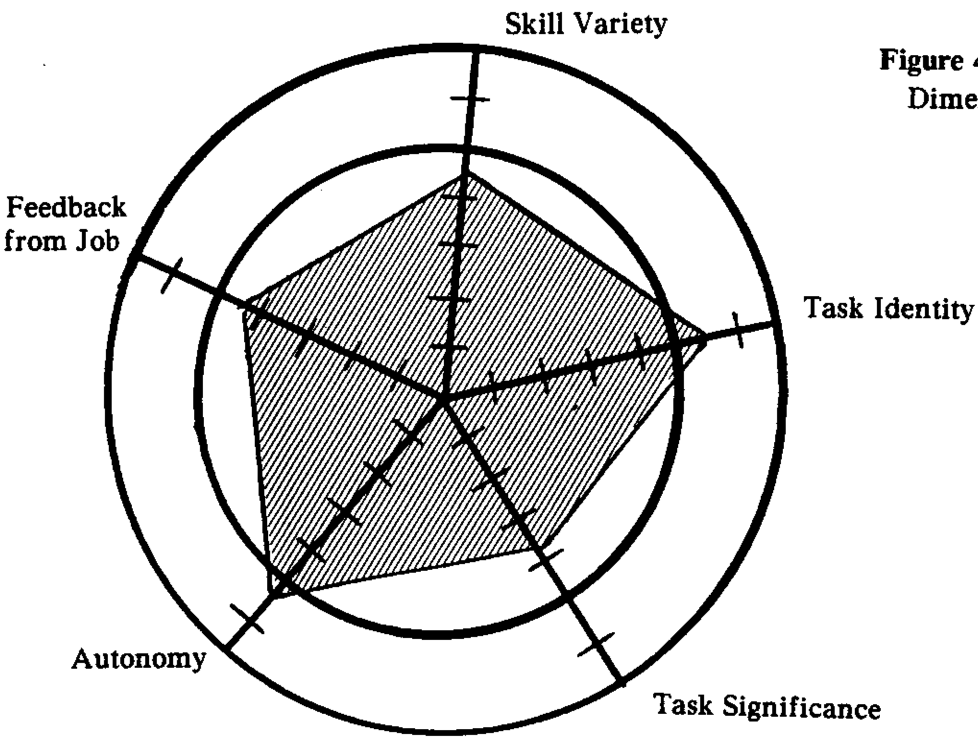


Figure 4. Deficient Core Job Dimensions for Problem Company.

The following action was taken. Using the framework of the five core job dimensions, management used the brainstorming technique to generate over 50 approaches for enhancing the deficient job dimensions: skill variety, task significance and feedback. In a subsequent evaluation session, the following ideas are representative of those selected for implementation.

To increase skill variety, employees were assigned to more than one application and received additional training in techniques for database/data communications. Task significance was increased by arranging for formal presentations from higher level users of their systems on the impact of these systems on company objectives. Both feedback and task significance were increased by better communication of organizational goals to employees. More formal tracking mechanisms were established to improve the quality of feedback.

Although too soon to measure results in this firm, the process is identical to that we've used over the past seven years for improving motivation in other computer job types. For example, Hartford Insurance Company reduced turnover from 17.6% to 8.8% by this process (Lasden, 1981). Dr. Paul Daverio, Vice President for MIS at Owen Corning Fiberglas Corporation, had the following comments about results from use of this motivation procedure in his organization.

"There were literally dozens of examples in which survey scores substantiated conditions we knew existed -- both favorable and unfavorable. This fact resulted in immediate credibility of the instrument among our management group. Since the instrument proved accurate for the characteristics we were already aware of, we took seriously the things it indicated of which we were not aware. And here is where we definitely benefited from new, credible data -- new information for which we could, and did, take action," (Daverio, 1981).

Need for Improved Feedback

In two categories, SIGSOFT survey participants varied little from their peers who make up the other national norms. In all 18 job categories, feedback, in general is perceived to be inadequate, as shown in Figure 5. So is feedback on goals.

One of the causes is the low social need strength (SNS) of personnel in the computer field. SNS

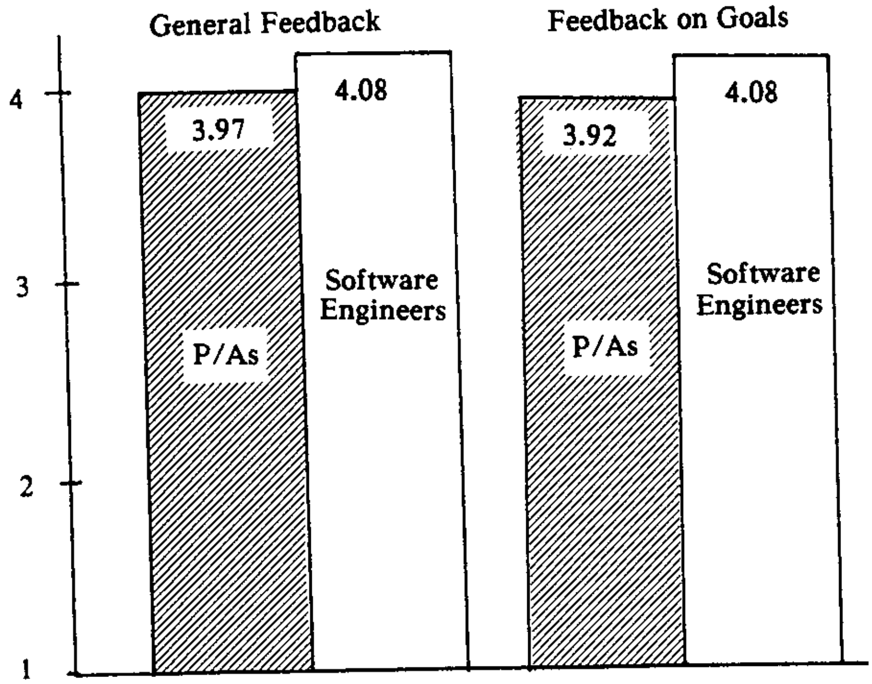


Figure 5. Problems in Supervisory Feedback.

is a measure of an individual's need for social interaction. While software personnel's national norm for GNS is higher than any of the 500 jobs measured by Hackman and Oldham, the SNS is lower than any of the other 500 jobs. SNS for SIGSOFT survey respondents averages 4.29, and is not significantly different from the P/A norm of 4.20. Standard deviation is low, again indicating a homogeneous population.

Persons with low need for social interaction do not interact as frequently; hence fewer opportunities for feedback occur in the computer field. Intensifying this problem is the greater need for feedback for employees with high growth need. Because goal- orientation is another characteristic of high GNS employees, they desire frequent feedback on goal performance. The feedback problem is important and needs management attention.

Profile of SIGSOFT participants

Table 3 provides the demographics for the SIGSOFT survey participants compared to the national norms for P/As. Over half of the SEs have masters degrees or higher, compared to only seven percent for P/As. The male/female ratio was essentially equal, 61.8% male compared to the P/A norm of 62.5%. The SIGSOFT respondents were somewhat younger and had slightly less longevity with their present firm.

One might suspect that the difference in GNS between SIGSOFT survey participants and the P/A norms is due to the lower education level of the latter group. Our prior research does not support this hypothesis. For our national database of more than 8,000 persons, GNS is not significantly different for bachelors and masters degree holders. Nor is GNS significantly dif-

Table 3. Demographics of SIGSOFT.

Respondent Characteristrics	**Survey Percentages** SIGSOFT	P/As
Education		
Some College	9.5%	43.5%
Baccalaureate Degree	33.7%	49.4%
Masters Degree or Higher	56.8%	7.1%
	100.0%	100.0%
Age		
Under 30	37.1%	36.3%
30-39	48.8%	51.7%
40-49	9.5%	14.7%
Over 49	4.6%	7.3%
	100.0%	100.0%
Years With Their Company		
Less than 1	13.7%	17.5%
1 to 4	48.1%	36.6%
4 to 8	17.2%	22.0%
8 to 12	10.2%	11.3%
12 to 16	7.4%	4.5%
Over 16	3.4%	8.1%
	100.0%	100.0%

ferent for scientific/mathematic software developers versus business application software developers. Apparently persons with higher GNS select themselves out, or are selected by management, for the richer work of software engineering.

CONCLUSIONS

To improve the process of matching individual growth need with the complexity of assigned tasks, managers of software engineers need to evaluate separately their subordinates' skills/abilities from their need for achievement. Some very qualified employees do not have concomitant amounts of drive or ambition. They are competent employees who perform quite satisfactorily at medium- scope assignments. Other employees with similar skills, but who have a high need for growth, need assignments which stretch them. Even though the mean GNS of all SEs is high, relative to other computer occupations, and even though the standard deviation is relatively low, there is enough variation to present a GNS/JMC matching problem for managers of these employees.

Because software engineers have the highest GNS of any occupation ever researched, managers must be continuously seeking new ways to properly utilize the potential of this very talented group of employees. Evaluation of assignments in the framework of the five core job dimensions enables software engineering managers to reduce or enlarge the scope of work to meet the individual growth needs of employees.

The process of matching GNS/JMC for other technical jobs in the computer field has resulted in significant improvements in motivation and productivity. The software engineering field has the same opportunity for improvement.

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