Factors Affecting Software Developers’ Performance: An Integrated Approach

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Abstract

Software developers’ performance has a direct impact on software development productivity. An understanding of the factors that affect this performance could help determine where to concentrate management efforts (and related financial resources) from a practical standpoint, and where to focus research efforts from an academic perspective. To gain further insight into these factors, this study extends prior research by integrating elements from expectancy theory, goal-setting theory, and organizational behavior specific to the software development process. The research results provide new insights regarding the relative importance of how expectancy theory, goal-setting theory, and individual characteristics affect the perceived performance of software development professionals. These preliminary findings indicate that goal-setting theory may have complex implications for software development performance. Goal difficulty has a negative relationship to performance but a positive relationship to effort. Because of this off-setting effect, the degree of goal difficulty has a relatively small overall effect on performance. Goal clarity also has a relatively small effect on performance. Individual ability has the strongest direct effect on perceived performance, more than twice as strong as the effects of work effort, personality dimensions, and perceived characteristics of the task. High achievement needs were directly related to both effort and perceived performance, whereas self-esteem and locus of control have a direct relationship to perceived performance.

Keywords: Management, productivity, software development performance, expectancy theory, goal-setting theory

ACM Categories: K.4.2, K.4.3, K.6.1, K.7.1

Background and Introduction

Two theoretical behavioral approaches, expectancy theory (Mitchell, 1974; 1979; 1982) and goal-setting theory (Locke and Latham, 1990), have often been used to examine relationships between variables that affect individual motivation and performance. These theories identify circumstances that motivate an individual to exert a greater level of work effort that leads to higher work performance and increased productivity. There is also a large body of theoretical and empirical literature that addresses the effects of individual characteristics on performance. A portion of this work is directly focused upon the effects of individual characteristics on software developers’ performance. McGarry (1984) and Curtis (1986) show that individual leadership characteristics are correlated with software developers’ perceptions of job satisfaction. They recommended that further research be conducted to evaluate the impact of individual characteristics on job-related outcomes. Baroudi (1985) investigates the effect of role variables on software developers’ turnover intentions. He suggested that better models be developed to explicitly evaluate the job-related behavior of individual software developers. The results of a nation-wide study by Couger and

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1 This research was sponsored by the Software Engineering Research Center (SERC), which is a joint center comprised of industry affiliates, NSF, the University of Florida, and Purdue University.
Zawacki (1980) indicate that data processing professionals have higher individual growth needs and lower social needs than the general population.

In a later survey of ACM's Special Interest Group on Software Engineering, Couger (1986) found that software engineers have the highest achievement needs of any computer-related group previously surveyed. Further, a more recent study conducted by the Microelectronics and Computer Technology Corporation (MCC) stresses the crucial role of individual talent and skill on project performance (Curtis, et al., 1988). Results such as these led Reneau and Grabski (1987) to stress the need for additional research directed at the effects of individual characteristics on the system development process. Using worldwide projected software cost trends, Boehm (1987) predicts that a 20 percent improvement in software productivity would be worth $90 billion worldwide in 1995. The work motivation and performance of software development professionals, therefore, is an important area of research in the software development literature.

The purpose of this paper is to develop an integrated approach, combining concepts from expectancy theory, goal-setting theory, and individual characteristics research, to examine factors that affect the performance of software development professionals. A knowledge of the relative importance of how these theories affect software development performance could help determine where to concentrate management efforts (and related financial resources) in order to motivate software developers to become high performers in an organization. From an academic perspective, the results of this study provide insights regarding where to focus future research efforts aimed at further understanding factors that impact the performance of software development professionals.

Conceptual Framework

Integrated research model

The research just cited shows the effects of several independent variables on performance-related dependent variables using separate behavioral models. Our research develops an integrated model that permits the assessment of the relative effects of the level of effort, goal characteristics, and individual characteristics on performance to facilitate a greater understanding of the complexities inherent in the software development process. The research model is constructed from three sets of concepts: expectancy theory, goal-setting theory, and individual characteristics. Because of the inherent complexity of integrating three different, yet related, lines of research, the research model is limited to addressing several key elements from each of these concepts. The variables and the nature of their relationships are summarized in Figure 1.

Expectancy theory

Expectancy theory continues to be widely used to examine motivational issues (Baker, et al., 1989; Brownell and McInnes, 1986; Butler and Womer, 1985; Harrell and Stahl, 1984; Kaplan, 1985; Nickerson and McClelland, 1989). Much of the interest in expectancy theory research stems from the belief that highly motivated individuals will exert higher effort levels and consequently will tend to perform at higher levels than their less motivated contemporaries. The expectancy theory component of the research model is shown in Figure 1a.

As shown in the equation, performance (P) can be described as a function of an individual's effort-level (E), ability (A), and role perceptions (R) (Ferris, 1977; Lawler and Suttle, 1973).

\[ P = f (E, A, R) \]

Ability (A) refers to factors such as the person's native intellectual capabilities and the quality of his or her formal education or training. Ability is hypothesized to be positively related to performance (Path 6). Role ambiguity (R) refers to how well individuals understand their role in the organization. Ideally, the individual knows the limits of assigned authority, what is to be accomplished, and how performance will be judged. Role ambiguity is hypothesized to be inversely related to effort (Path 7). Effort (E), in turn, is hypothesized to be positively related to performance (Path 8).

The performance model (see equation) aims at explaining differences in performance between individuals. The equation posits that individuals exert different effort levels, possess different abili-
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Figure 1. Integrated Research Model

...levels, and have different role perceptions. As a result, they are expected to exhibit different levels of performance. In essence, the equation implies that, if individual differences in ability and role perceptions are considered, different effort levels can be expected to directly affect work performance (Lawler and Suttle, 1973). Prior research has not always supported this contention. Ferris (1977), for example, concludes that after considering individual differences in ability and role perceptions, effort level has no impact upon the work performance of professional public accountants.

Goal-setting theory

Goal-setting theory research shows that expectancies about the level of success may also be related to the clarity and difficulty of work requirements (Carroll and Tosi, 1973; Locke and Latham, 1990; Locke, et al., 1981). The goal-setting theory component of the research model is depicted in Figure 1b. When tasks are unclear, the ambiguity is related to task anxiety, hesitation in making decisions, and lower performance. Goal specificity should reduce role ambiguity (Path 5) (Locke and Latham, 1990). Role ambiguity, in turn, is inversely related to effort level (Path 7) (Porter and Lawler, 1968). As goals become more difficult, the individual exerts greater effort (Path 4), which should also result in improved performance (Path 9) as long as goals remain attainable (Locke and Latham, 1990).

The theory of goal setting and its supporting research have been summarized and reviewed by Locke and Latham (1990). Early empirical work focuses largely on tasks in laboratory studies that are relatively simple (Landy and Becker, 1987). Studies of more complex tasks, however, have failed to produce the same strong results as those studies using simple tasks. For instance, Wood, et al. (1987) analyzed the results of over 70 studies with various levels of task complexity and found that the magnitude of goal ef-
Figure 1a. Expectancy Theory Model

Figure 1b. Goal-Setting Model
ffects on performance was greater on simple tasks than on complex tasks.

This study addresses the job performance of software development professionals. Goal theory, however, has mainly addressed the issue of task performance and is only a start toward understanding job performance. Job performance is a much more encompassing global concept than task performance. In the context of software development, job performance relates to more than technical tasks such as program coding, writing design specifications, and debugging programs. It also encompasses aspects such as determining system requirements, communicating with peers and users, and translating "soft" user needs into "hard" design criteria. Since the tasks inherent in software development are considerably more complex than tasks performed in most prior goal theory studies, the impact of goal characteristics may differ from some of the prior study results.

**Individual characteristics**

Software developers' performance may also be affected by individual characteristics. The individual characteristics dimension of the research model is shown in Figure 1c. Performance has been related to an individual's need for achievement, locus of control, and self-esteem (Mitchell, 1974; 1979; 1982). *Need for achievement* is the extent to which the person values success (McClelland, 1961). Individuals with high achievement needs prefer to work in situations where the desired results are clear. Individual achievement needs have been shown to be positively related to both effort (Path 2a) and performance (Path 2b) (Mitchell, 1979; Porter and Lawler, 1968; Steers, 1975; Steers and Porter, 1983). *Locus of control* refers to whether people believe that their fate is controlled by external factors or by the people themselves. There is evidence that people with a strong internal locus of control (where they believe they control their own fate)
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exert greater effort (Path 3a) and higher performance (Path 3b) than those with a strong external locus of control (where they believe their fate is controlled by others) (Anderson, 1977). Self-esteem is a person's sense of self-worth. High self-esteem is proposed to be positively related to both effort (Path 1b) and performance (Path 1a). Evidence shows that managers with high self-esteem report higher levels of performance when they have difficult goals to achieve than those with low self-esteem (Carroll and Tosi, 1973). However, argument shows that an individual's need for achievement and self-esteem may moderate the relationship between work performance and the characteristics of work goals.

Method

Subjects

The data for this study were gathered at three major software development organizations located in the midwest, southwest, and southeast United States. These firms are involved with a wide spectrum of software development projects ranging from embedded systems on classified government contracts to telecommunications for public telephone systems and payroll systems for business organizations. All three firms are advocates of the principles of software engineering, and they use the term software engineer interchangeably with software developer. The respondents actually participated in the total software development process from problem definition through debugging and implementation. Because these three firms support the concept of their software developers' involvement with a project from its beginning to its end, the respondents provided a homogeneous sample knowledgeable of the entire software development process. The evidence of this homogeneity was apparent from the separate analyses performed for each company. There were no statistically significant differences between the demographics, individual characteristics, or other variables measured for the respondents. Responses were therefore combined across the three firms for the subsequent analyses reported below. This finding also provided evidence for the generalization of the results across at least the three firm environments. These responses, however, might differ from those of subjects in other firms that do not advocate the software engineering approach to developing software.

The research questionnaire was administered to software developers on-site at two of the locations and administered by mail at the third. Three hundred thirty-five useable responses were obtained. On-site administration elicited 105 useable responses (53 of 54 in Company A and 52 of 53 in Company B). On-site administration of the test instrument at Company C was not feasible because of the large number of software developers that participated. Therefore, questionnaires, with return envelopes, were distributed to 500 individuals through the company mail system. Of these, 230 useable responses (46 percent) were received. Table 1 shows summary descriptive statistics for the 335 respondents.

All respondents were informed of the purpose of the study and were asked to identify themselves on the survey instrument so that the researchers could relate their responses with internal company information. They were, however, told that only summary results would be provided to their firm and that their anonymity would be protected. Each firm, in addition, provided a cover letter signed by the appropriate vice president that encouraged the respondents to participate in the study, stated that internal data would be used in addition to the survey data so their individual assessments could be correlated with internal company information, and reinforced that individual anonymity would be protected by the researchers. The management of Company B also provided confidential managerial performance ratings of the subjects, which made it possible to relate an independent assessment of performance with the self-reported measure of performance obtained from the respondents.

Measures

A preliminary questionnaire was pilot-tested with 17 software developers to assess logical inconsistencies, ease of understanding, and task relevance. There were some modifications to the original instrument to clarify the meaning of particular sections. None of these responses were used in the analysis reported in this study.

Performance

Perceived performance was measured by a single item, which asked each subject to com-
Table 1. Descriptive Statistics for Respondents

<table>
<thead>
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<th>Category</th>
<th>Number</th>
<th>Percent</th>
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<tr>
<td>Female</td>
<td>89</td>
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<tr>
<td>HS Diploma + Some College</td>
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<td>16</td>
</tr>
<tr>
<td>Bachelors Degree</td>
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<td>45</td>
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<tr>
<td>BS + Some Graduate Work</td>
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<td><strong>Age</strong></td>
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</tr>
<tr>
<td>Mean</td>
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<tr>
<td>Standard Deviation</td>
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<tr>
<td>Mean</td>
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</tr>
<tr>
<td>Standard Deviation</td>
<td>6.9 years</td>
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</table>

To compare his or her overall job performance with others in the firm at the same level in the same specialty area. A nine-point scale was used, with anchors ranging from "very inferior, the very worst" to "very superior, the very best."

While "objective" performance measures or management ratings are desirable indicators of performance, there is evidence that self-reported performance is useful for research of the type done here. One study on the accuracy of self-appraisals found that self-appraisals are as predictive as other assessment methods (i.e., psychological tests, past performance, and peer ratings) with which they are compared (Shrauger and Osberg, 1981). Another study showed that self-appraisals conducted for the purpose of distributing rewards are more lenient than those conducted for research purposes (Farh and Werbel, 1986). However, the same study showed that leniency diminishes when individuals are informed that their self-appraisals will be evaluated against objective records, as is the case in this study.

A recent field evaluation concludes that though self-assessments may be inflated, they contain little halo effect; and inflated ratings do not necessarily contradict accuracy of assessment (Fox and Dinur, 1988). An empirical investigation of self-appraisal-based performance evaluation concludes that lenient self-appraisals are likely to occur when they lead to some personal gain or when no independent performance measures are available (Farh, et al., 1988). The level of ratings, however, should not influence validity unless there is severe restriction-of-range. Another investigation on assessing the utility of self-evaluations of work performance suggests that in theoretical studies of job performance, the researcher is probably well-advised to include self-descriptions as a source of data (Thornton, 1980).

A characteristic of the performance measure is that it is a single item, rather than a multiple-item measure. The use of a single-item measure for performance continues to be a topic of academic controversy in the psychological literature (Cascio, 1987). This was not foreseen as a problem for this study, however, because it has been demonstrated that single items that capture the global meaning of a concept may be effective indicators of performance (Scarpello and Campbell, 1983). While it is not possible to estimate reliability with conventional methods such as alpha coefficients (Cronbach, 1951), there is some evidence of the validity of this measure for this study. It was possible to correlate the respon-
dent's self-assessments with an independent managerial rating of performance for the software developers in Company B. The managerial performance rating was highly correlated with the self-rating ($r = .51, p = .0001$), suggesting that there was criterion-related validity for using this measurement at Company B. Further, there were no significant differences between the performance self-assessments of individuals at Company B and the other two companies, which lends further credibility to the validity of this measure.

**Effort**

Individual effort was assessed with an instrument based on expectancy theory. Expectancy theory emphasizes the cognitive aspects of motivation (Vroom, 1964). Noting this aspect of the theory, Mitchell and Beach (1977) and Zedeck (1977) proposed that judgment modeling techniques frequently employed to examine cognitive issues could be used for an examination of expectancy theory. Stahl and Harrell (1981; 1983) developed such a judgment modeling approach for an examination of the explanatory ability of the expectancy theory models. Using the same approach for this study, an individual's effort level was assessed with an instrument based on the expectancy theory of motivation. This instrument operationalizes Vroom's (1964) theoretical model of expectancy theory. Using this instrument, subjects provided instrumentality, valence, expectancy and effort-level information for their current job (see Appendix A for a description of the instrument).

First, subjects were asked to indicate their probability estimates of the likelihood of a set of second-level job outcomes (e.g., frequently work overtime to meet deadlines, be admired by peers and colleagues). Keeping these probabilities in mind, they were then asked to indicate the valence of being a highly effective work performer (Response A).

Following Response A, the respondent was asked to indicate the likelihood (probability) that, if a great effort were exerted, he or she would be a highly effective work performer. Then the subject indicated the level of effort he or she would exert, given the circumstances of his or her current job (Response B).

This measure is not a typical, multi-item scale from which a score is obtained by some mathematical combination of items. It is designed to take the subject through the sort of calculus implied in expectancy theory. This behaviorally oriented measure is very consistent with the expectancy theory notion of motivation and has been validated by a number of prior studies. Stahl and Harrell (1981) performed two separate experiments using the instrument and found that this approach explains significant portions of the variance in an individual's effort level ($R^2 = .77$ and .84). Additional studies also found that the measure is a good predictor of effort: Harrell and Stahl (1984) report that $R^2 = .74$, and Harrell, et al. (1985) indicate $R^2 = .85$.

**Ability**

Ability was operationalized with two items. One item asked the software developer to compare his or her level of native intellectual ability with others in the firm at the same level in the same specialty area. Self-evaluations of ability are valid indicators, given certain conditions (Mabe and West, 1982). First, the participants must be informed that the self-evaluation would be compared with criterion measures. Second, the self-evaluations should remain anonymous. Third, the subjects must compare themselves with others. Fourth, the self-evaluations should be related to a specific ability or category; the participants' self-evaluations of ability relate to their native intellectual ability. A fifth factor suggested by Mabe and West (1982), i.e., the rater's experience with self-evaluation, is unknown for this study. With the exception of the last factor, all of the above conditions were met in this study.

The second item was a rating of the quality of the respondents' formal training or education relative to others in their firm at the same level in the same specialty area. Rasch and Harrell (1991) found that these two items constitute a reasonable measure of ability in a study involving accounting professionals. They originally proposed three items to measure ability: (1) native intellectual ability, (2) quality of academic education, and (3) extent of academic education (in years). Their analysis shows strong support for the first two, but very weak and statistically insignificant support for the extent of academic education. Based on their findings we elected to include native intellectual ability and quality of academic education as items to measure abili-
predictability. Another reason we chose these two items was because their study was also concerned with global concepts of performance and ability and their subjects included consulting/information system professionals. The measurement was actually a nine-point scale, with anchors ranging from "very inferior, the very worst" to "very superior, the very best." In the data analysis, the two items were shown to "load" on one conceptual factor—ability. The factor loadings for both variables were statistically significant at \( p \leq .05 \) (see Appendix B).

Role Ambiguity
Role ambiguity was measured using the six-item role ambiguity scale developed by Rizzo, et al. (1970). Role ambiguity is the degree to which the individual has knowledge about what behavior is expected and whether there are guidelines concerning appropriate behavior. The internal reliability (Cronbach, 1951) was very high (\( \alpha = 0.89 \)).

Goal Attributes
There is ample theory and evidence that specific, challenging goals lead to higher performance than general, easy goals (Carroll and Tosi, 1973; Latham and Locke, 1979; Locke, et al., 1981). The Task-Goal Attributes Scale developed by Steers (1975) was used to measure goal specificity (\( \alpha = 0.83 \)) and goal difficulty (\( \alpha = 0.81 \)).

Individual Characteristics
Three individual characteristics were measured: need for achievement, locus of control, and self-esteem. Need for achievement was measured using a five-item scale developed by Steers and Braunstein (1976) (\( \alpha = 0.73 \)). Locus of control refers to the degree to which individuals feel they can control their own "destiny." Individuals with a strong locus of control feel that most things that happen to them are influenced by themselves, whereas individuals with a low locus of control feel they have little or no control over things that happen to them. Rotter’s (1966) 15-item measure of locus of control was used for this study (\( \alpha = 0.71 \)). Self-esteem was measured with the 25-five item adult form of Coopersmith’s (1967) self-esteem scale (\( \alpha = 0.80 \)).

Analysis
The simple correlation matrix for the variables is shown in Table 2. Structural equation modeling using LISREL VII (Joreskog and Sorbom, 1988) was applied to test the fit of the research model (shown in Figure 1) to the data collected using sample covariance matrices. Two-stage least squares and maximum-likelihood procedures yielded initial and final parameter estimates, respectively. This analysis provides direct measures of the degree to which theoretical constructs are related, the extent of errors in variables and equations, and the relationships between constructs and the operationalization of

<table>
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<th>Variable</th>
<th>PE</th>
<th>EF</th>
<th>RA</th>
<th>AN</th>
<th>LC</th>
<th>SE</th>
<th>GS</th>
<th>GD</th>
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<td>.20*</td>
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</table>

*Statistically significant at \( p \leq 0.05 \).
those constructs (Pedhazur, 1982). LISREL analysis permits the explicit incorporation of scale reliabilities into the measurement error terms, providing a greater degree of statistical control than classical path analytic techniques. A description of the LISREL structural model and a discussion of its statistical properties are contained in Appendix B.

Because the role ambiguity and goal specificity scales were highly correlated \( r = -0.79 \), a factor analysis was performed using their individual scale items (six for role ambiguity and three for goal specificity). The scale-item scores were adjusted to ensure that they went in the same direction. All nine items loaded heavily on a single factor, which is called goal clarity in the empirical performance model. The internal reliability (Cronbach, 1951) for the goal clarity scale was very high \( (\alpha = 0.92) \).

**Results**

Results of the analysis are shown as the empirical performance model (Figure 2). The proposed linkages of the research model (Figure 1) were tested at a statistical significance level of \( p \leq 0.05 \). All significant linkages were retained in the empirical performance model.

The strength of the relationships among the variables in the empirical performance model (Figure 2) is represented by standardized solution coefficients. These coefficients could range from \(-1\) to \(+1\) and provide meaningful measures to assess the relative strength between variables. The empirical performance model explains 54 percent of the variance in the reported individual performance levels \((R^2 = 0.54)\).

The total effect of a variable on software developers' perceptions of performance is due to both direct and indirect effects of intervening variables. An individual's achievement needs, for example, have a total effect of 0.26 on perceived performance (direct effect of 0.18 and indirect effect of 0.08). Indirect effects are calculated by combining their effects with intervening variables. The indirect effect of achievement needs on performance is computed by multiplying the direct effect of achievement needs on effort by the direct effect of effort on performance. The total effects on performance for all variables are shown in Table 3.

As shown, high achievement needs were positively related to effort and perceived performance. Those individuals with a strong sense of control over their lives and high self-esteem also had higher perceived performance than their counterparts. The hypothesized relationships between effort and self-esteem and locus of control (Paths 1b and 3a in Figure 1), however, were not supported in this study.

As predicted, goal clarity was positively related to an individual's effort level. Goal difficulty was also positively related to effort, as predicted. The expected positive effect of goal difficulty on performance was not, however, found by this research. In fact, goal difficulty was negatively related to performance. As predicted, both individual effort and perceived ability were positively related with software developers' perceptions of performance.

Individual ability had the strongest total and direct effect \((0.54)\) on reported performance. This result is consistent with the finding by Hunter and Hunter (1984) that the best single predictor of performance is ability. Effort was less strongly related to software developers' perceived performance, though still a very important factor (total effect = 0.21).

Achievement needs had the second greatest total effect on perceived performance \((0.26)\). The relatively small total effect of goal difficulty on perceived performance \((-0.07)\) was due to a positive indirect effect through effort \((0.04)\) and the offsetting negative direct effect on performance \((-0.11)\). Goal clarity had the smallest effect on perceived performance \((0.04)\).

**Discussion**

Prior to discussing the results, there are three methodological issues in this study that warrant mention. First, this research employs a structural equation modeling technique, but because the data are cross-sectional, the causal links between the variables should be considered with caution and subjected to additional future research. Second, with scales of the type used here there is the possibility of common method variance, which would inflate the relationships between the variables. This does not appear to be a problem with this data for two reasons. First, if common method variance was a serious problem, the zero
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Figure 2. Empirical Performance Model

Table 3. Empirical Performance Effects

<table>
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<th>Relation</th>
<th>Direct Effect</th>
<th>Indirect Effect</th>
<th>Total Effect</th>
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<td>Achievement Needs With Performance</td>
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<td>0.08</td>
<td>0.26</td>
</tr>
<tr>
<td>Self-Esteem With Performance</td>
<td>0.15</td>
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<td>0.15</td>
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<td>Locus of Control With Performance</td>
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<td>0.11</td>
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<td>Goal Difficulty With Performance</td>
<td>-0.11</td>
<td>0.04</td>
<td>-0.07</td>
</tr>
<tr>
<td>Effort With Performance</td>
<td>0.21</td>
<td>---</td>
<td>0.21</td>
</tr>
<tr>
<td>Ability With Performance</td>
<td>0.54</td>
<td>---</td>
<td>0.54</td>
</tr>
</tbody>
</table>
order correlations (see Table 3) would be more similar than is the case. The range of correlations is from .01 to .79. Second, a test for common method variance revealed no indication of a unidimensional factor (Podsakoff and Organ, 1986). The third methodological issue relates to the variables included in this study. Although the research model integrates expectancy theory, goal-setting theory, and individual characteristics, other variables not assessed in this research may affect performance. The model does not consider environmental factors or situational constraints. Future research should include such variables to more fully understand the contextual and individual effects on software development performance.

The performance model developed in this study extends prior research by integrating elements from expectancy theory, goal-setting theory, and organizational behavior specific to the software development process. This research is in line with the arguments of Curtis, et al. (1988), Goldstein and Rockart (1984), and McGarry (1984) where individual characteristics are the predominant factors affecting software developers’ performance. Of these factors, ability has the strongest direct effect on perceived performance—more than twice as strong as the effects of work effort, personality dimensions, and perceived characteristics of the task.

Performance is also affected by the nature of the work goals in a relatively complex way. While goal difficulty is negatively related directly to performance, if the difficult goals lead to increased effort, then it is the increased effort (driven by the difficult goals) that has a positive effect on performance. Similarly, goal clarity has no direct effects on performance but appears to increase the individual’s level of effort and, subsequently, performance.

One reason that may account for the differences between these results and goal-setting theory is the complexity inherent in software development. Goal-setting theory, as explicated by Locke and Latham (1990), is developed largely from experimental studies in which the tasks were very simple. These studies demonstrate that the effects of goal specificity and difficulty are not nearly as strong in the case of more complex tasks.

Another possibility is that the difficulty of the tasks faced by the subjects in this situation varies more widely than in a laboratory setting, thus creating the perception of unattainability by the subject. A third possibility is that this study measured software developer’s perceived performance and perceived ability. An individual’s perceived performance may tend to drop as goals become more difficult, although their actual performance may increase (Locke and Latham, 1984). This phenomenon is due to an increase of individual effort, which results in higher performance on an absolute scale; yet the individual may feel a sense of less accomplishment when measured against the new (higher) standards. Because this study measures an individual’s perceptions at a point in time, as compared to a perception over changing time periods and changing goals, this phenomenon may not exist in this research study.

The research results provide new insights regarding the relative importance of how expectancy theory, goal-setting theory, and individual characteristics affect the perceived performance of software development professionals. These preliminary findings indicate that goal-setting theory may have complex implications for software development performance. Goal difficulty had a negative relationship to performance but a positive relation to effort. Because of this offsetting effect, the degree of goal difficulty had a relatively small overall effect on performance. Goal clarity also had a relatively small effect on perceived performance. Further research is needed to gain additional insight into the extent to which goal-setting theory affects software development performance.

Individual characteristics were found to be related to both effort and performance. High achievement needs were directly related to both effort and perceived performance, whereas self-esteem and locus of control had a direct relation to perceived performance. Since these individual characteristics had a relatively large combined effect on perceived performance, further research is needed to provide greater insight into potential causal links among these relationships and the reasons for such causality.

Summary and Conclusions
This study developed an empirically based model to analyze factors that affect the perceived performance of software developers. A number of
significant hypotheses can be generated from this model to be empirically validated, or refuted, by future research. Several of these hypotheses are related to the impact of goal-setting theory on the performance of individual software developers. The results indicate that goal difficulty had a negative relationship to performance but a positive relationship to effort. Because of this off-setting effect, the degree of difficulty of organizational goals had a relatively small overall effect on performance. Goal clarity, in addition, also had a relatively small overall effect on performance. Future research is needed to gain additional insight into this finding. This research could focus on establishing causal relationships based on the tenets of goal theory. The relative strength of these relationships could then be compared to the strength of both individual motivation and individual differences regarding their effect on software developers' performance.

The results of this study also indicated that a software developer’s ability and individual need for achievement were the two strongest factors determining individual performance. Further research needs to be conducted to investigate this finding in greater detail, specifically with respect to causal relationships between individual characteristics and work performance. Increased knowledge of these relationships could provide management insight into where the “high payoff” areas exist to further enhance the performance of software developers.

The study also indicated that a software developer’s motivation or level of effort was another important factor in determining individual performance. Although this study used an expectancy theory model to determine the individual motivation level, further work is needed to determine specific intrinsic and extrinsic factors that impact the motivation of software developers. These findings could provide valuable insight into effective management techniques and approaches to improve the software development process.

The above findings identify a number of issues related to both the relative effects of factors that affect perceived performance of software development professionals and the measurement of those factors. Extension of this work could have a major impact on understanding and improving software development performance from both a theoretical and an applied perspective. It is hoped that this initial study will stimulate further examination of these issues.

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Appendix A
Motivation Level Information for Current Job

Your Current Job

In the following situation, you are asked to provide likelihood (probability) information for your current job. Any response ranging from $p = 0\%$ (never) to $p = 100\%$ (always) is appropriate. If, however, you can’t estimate these likelihood (probability) values precisely, you may respond with either $p = 10\%$ (low) or $p = 90\%$ (high).

If you are a highly effective performer in your current job, the likelihood (probability) that you will

- frequently work overtime to meet deadlines is ...................... ($p = \_\_\_\_\_\_\_\_$)
- be admired by your peers and colleagues is ...................... ($p = \_\_\_\_\_\_\_\_$)
- be assigned challenging duties that increase your professional competence is ...................... ($p = \_\_\_\_\_\_\_\_$)
- get more economic rewards than in another job is ...................... ($p = \_\_\_\_\_\_\_\_$)
- have good future job security is ...................... ($p = \_\_\_\_\_\_\_\_$)
- be promoted to a more influential job is ...................... ($p = \_\_\_\_\_\_\_\_$)

Response A: With these factors in mind, indicate the attractiveness to you of being a highly effective performer in your current job.

-5 -4 -3 -2 -1 0 +1 +2 +3 +4 +5
Very Unattractive Very Attractive

Further Information: If you exert a great effort, the likelihood (probability) that you will be a highly effective performer in this job is:

($p = \_\_\_\_\_\_\_\_$)

Response B: With the information above in mind, how much effort do you make to be a highly effective performer in your current job?

0 1 2 3 4 5 6 7 8 9
Zero Average Great
Effort Effort Effort
Appendix B

Analysis Using the LISREL Model

In this paper, the Joreskog-Keesling-Wiley model, commonly known by the copyrighted name of the computer program LISREL VII (Joreskog and Sorbom, 1988), was used. Detailed results of the analysis are contained in this appendix.

Empirical Performance Model: \[ \eta = \beta \eta + \Gamma \xi + \epsilon \] (A1)

Where:

\[ \eta = \begin{bmatrix} \text{effort} \\ \text{performance} \end{bmatrix} \]

\[ \xi = \begin{bmatrix} \text{self-esteem} \\ \text{achievement needs} \\ \text{locus of control} \\ \text{goal difficulty} \\ \text{goal clarity} \\ \text{ability} \end{bmatrix} \]

\[ \beta = \begin{bmatrix} .00 & .00 \\ .21 & .00 \end{bmatrix} \]

\[ \Gamma = \begin{bmatrix} .00 & .39 & .00 & .19 & .19 & .00 \\ .15 & .18 & .11 & -.11 & .00 & .54 \end{bmatrix} \]

\[ \epsilon = \begin{bmatrix} .71 \\ .46 \end{bmatrix} \]

Where \( \eta \) represents a vector of latent dependent variables, \( \xi \) represents a vector of latent independent variables, \( \beta \) and \( \Gamma \) are coefficient matrices, and \( \epsilon \) is a random vector of residuals (errors in equations, random disturbance terms).

Based on the proposed Integrated Research Model (Figure 1) \( \beta(1,1), \beta(1,2) \) and \( \beta(2,2) \) were initially set to zero to test the proposed relationship between effort and performance. Since there are no proposed relationships between goal clarity and performance or effort and ability, \( \Gamma(2,5) \) and \( \Gamma(1,6) \), respectively, were also set to zero. Following the initial data analysis, \( \Gamma(1,1) \) and \( \Gamma(1,3) \) were also set to zero because there was no statistically significant relationship (\( p \leq .05 \)) between effort and either self-esteem or locus of control.

The Dependent Variable Measurement Model

This equation constitutes a measurement model for the dependent variables in the empirical performance model (Equation A1). In LISREL modeling, dependent indicator variables are designated as y,
Predicting Developers' Performance

\( \Lambda_y \) defines the structural relationship between the latent dependent variables and their indicator variables, and \( \epsilon \) represents the measurement error. The relationship between the dependent variables and the indicator (observable) variables used to measure them is captured by the following measurement model:

\[
y = \Lambda_y \eta + \epsilon
\]  \( \text{(A2)} \)

Where:

\[
y = \begin{bmatrix}
\text{effort level} \\
\text{perceived performance}
\end{bmatrix}
\]

\[
\Lambda_y = \begin{bmatrix}
1 & 0 \\
0 & 1
\end{bmatrix}
\]

\[
\eta = \begin{bmatrix}
\text{effort} \\
\text{performance}
\end{bmatrix}
\]

\[
\epsilon = \begin{bmatrix}
.00 \\
.00
\end{bmatrix}
\]

Because the indicator variable for effort was captured using a behavioral decision-making scenario and the indicator variable for performance was a single-item measure, it is not possible to estimate their internal error terms, \( \epsilon \). As is customary in LISREL analysis, these error terms are explicitly set to zero. As a point of interest, it should be noted that this procedure is exactly the same as is done implicitly using ordinary least squares linear regression techniques.

The Independent Variable Measurement Model

In LISREL modeling, independent indicator variables are designated as \( x \), \( \Lambda_x \) defines the structural relationship between the latent dependent variables and their indicator variables, and \( \delta \) represents the measurement error. The relationship between the independent variables and the indicator variables used to measure them is captured by the following measurement model:

\[
x = \Lambda_x \xi + \delta
\]  \( \text{(A3)} \)

Where:

\[
x = \begin{bmatrix}
\text{self-esteem} \\
\text{need for achievement} \\
\text{locus of control} \\
\text{goal difficulty} \\
\text{goal clarity} \\
\text{intellectual ability} \\
\text{quality of education}
\end{bmatrix}
\]
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Because five of the observed variables (self-esteem, need for achievement, locus of control, goal difficulty, and goal clarity) were measured using multiple-item scales, prior to the analysis the error terms for these variables were fixed at the quantity one minus their internal consistency (reliability) multiplied by the variance of each measure (Hayduk, 1987). This approach enables the explicit recognition of known measurement error to be incorporated into the structural equation model. For example, the internal consistency for self-esteem was .80. The variables were standardized to a mean of zero and a variance of one, therefore the error term for self-esteem was computed as $1^* (1 - .80) = .20$.

The remaining two observable variables (intellectual ability and quality of education) were combined in a factor model to estimate the conceptual variable, ability. The ability to combine factor analytic techniques and estimation techniques is enabled through the LISREL approach to data analysis. The squared multiple correlations of .95 and .22 (see $\Lambda_1$) indicate that these two observable variables "load" on the conceptual variable ability. The factor loadings for both variables are statistically significant at $p \leq .05$.

The assessment of fit of the Actual Performance Model to the data consists of three steps: (1) examination of the LISREL solution, (2) measures of overall fit, and (3) detailed assessment of fit (Joreskog and Sorbom, 1988). With respect to examination of the solution, careful attention was paid to parameter estimates, standard errors, correlations of parameter estimates, squared multiple correlations, and coefficients of determination. The main parameter estimates of interest in this study (standardized solution coefficients) are all significant. In addition, there are no identification problems that might be caused by highly correlated parameter estimates.

Measures of overall fit and detailed assessment of fit gave no indication of any problems. The $\chi^2$ measure was 10.75 ($p = .38$), which gave no statistical evidence to reject the model. In addition, an analysis of the magnitude of standardized residuals, and a q-plot of standardized residuals did not reveal any non-normality or identification problems with the model.