ANTECEDENT CONDITIONS LEADING TO ENGINEER PARTICIPATION IN CONTINUING EDUCATION AND SUBSEQUENT PERFORMANCE

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ABSTRACT

ANTECEDENT CONDITIONS LEADING TO ENGINEER PARTICIPATION IN CONTINUING EDUCATION AND SUBSEQUENT JOB PERFORMANCE

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This study investigated the impact of engineer perceptions of the climate for participation in continuing education (CE) and supervisor perceptions of the organizational reward structure for the maintenance of technical currency on engineer participation in CE. The effects of supervisor climate and reward structure perceptions on engineer climate perceptions were examined. The relationship between engineer participation in CE and performance was also explored. Neither engineer climate perceptions nor supervisor reward structure perceptions were related to actual engineer participation in CE. Supervisor and engineer climate perceptions were positively related. There was no relationship between supervisor reward and engineer climate perceptions. Engineer participation in CE had a significant impact on performance. Subsequent exploratory analyses found supervisor and engineer climate perceptions were positively related to engineer performance. Recommendations for research and theory on engineer participation in CE and performance including the use of improved CE, individual difference and environmental measures were discussed.

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This thesis is dedicated to my aunt, Jan Huegle, whose strength and courage I can only hope to emulate.

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INTRODUCTION

Personnel and management specialists have long been aware of the technical obsolescence problem (Evan, 1963; Rubin & Morgan 1967). Because of rapid changes occurring in technology, it has been posited that those engaged in technically-oriented work need to update job-related knowledge throughout the course of their careers (Evan, 1963; Zelikoff, 1969). It has been empirically demonstrated that the performance of engineers declines over time (Pelz & Andrews, 1966; Dalton & Thompson, 1971). Technical obsolescence has often been noted as a key factor, if not the primary cause, of this decline (Evan, 1963; Torpey, 1963; Machine Design, 1964; Dalton & Thompson, 1971; Kaufman, 1974a; Thompson, Dalton, & Kopelman, 1974; Sanders, 1974). The problem of technical obsolescence continues to be of widespread concern among technical professionals (Bornstein, 1983).

There remains a marked lack of research that directly addresses issues in technical obsolescence. The research that has been done is largely descriptive (Evan, 1963; Torpey, 1963; Dubin, 1972a) or based on anectdotal evidence and self-reports (Rubin & Morgan, 1967; Machine Design, 1964). There has been some work that identifies a number of factors relevant to long term engineer performance including early engineering ability (Spencer & Reynolds, 1961; Dunnette & Aylward, 1956; Owens, 1969); technical interest (Dunnette, Wernimont, &

Abrahams, 1965); academic attainment (Laumann & Rappaport, 1968; Perrucci, 1969; Kozlowski & Farr, 1986); and job challenge (Kaufman, 1974b; Kozlowski & Hults, in press; Kozlowski & Farr, 1986).

These studies address the problem of technical obsolescence through the mechanisms of selection (ability, technical interest and academic attainment) and job design (job challenge). Both of these areas have been researched in recent years (Schmitt & Schneider, 1983; Aldag, Barr, & Brief, 1981; Roberts & Glick, 1981; Griffin, Welsh, & Moorehead, 1981). There remains a third factor, participation in continuing education (CE), that is included in most discussions of preventing technical obsolescence, but remains largely unresearched.

Two issues are relevant to discussions of the CE-obsolescence relationship for engineers including factors that lead to engineer participation in CE and the impact of CE on subsequent engineer performance. Dubin (1972b) suggested that technical professionals should spend 20% of their time engaged in CE. Yet, evidence suggests a majority of technical professionals do not engage in CE (Rubin & Morgan, 1967; Kaufman, 1974a). Even more importantly, it appears that those most in danger of becoming obsolescent are the least likely to participate in effective CE (Kaufman, 1975). It has also not been demonstrated that participation in CE necessarily leads to improved performance for the technical professional (Kaufman, 1978). In summary it is unclear what factors lead to engineer particopation in CE and what the effects of that participation will be on subsequent engineer performance. These two topics are addressed in this thesis.

The previous research that has examined antecedent conditions leading to engineer participation in CE and technical obsolescence has been asystematic and atheoretical. This research does suggest though that both environmental factors (Kaufman, 1974a; Ritti, 1971a) and individual characteristics (Webster, Winn, & Oliver, 1956; Dunnette, et al., 1964; Kaufman, 1975) of engineers must be considered in studies of participation in CE and technical obsolescence. This study attempts to incorporate relevant individual and environmental variables in a model predicting engineer participation in CE. Interactional psychology provides a framework for examining the input of both environmental and individual difference factors on behavior. Interactional psychology postulates that the environment and the individual will interact to create various behavior patterns. The environment influences the individual and the individual influences the environment (Bowers, 1973). Behavior emerges from the interaction of these factors. This framework encourages the researcher to consider the potential richness and complexity of human behavior, while providing some preliminary guidelines for doing so.

An inherent difficulty in applying the interactive approach to a problem is determining which environmental and individual difference factors are relevant in the given context. Psychological climate perceptions are influenced by both environmental and individual characteristics (James & Jones, 1974; Schneider, 1975). They are psychologically based interpretations of the individual's environment (Mahoney, 1977; Naylor, Pritchard, & Ilgen, 1980; Schneider, 1980). These perceptions emerge from the interaction of the individual and the environment. Thus, climate perceptions incorporate the major components of the interactional perspective and should be a useful tool for operationalizing that perspective.

Climate perceptions are also used to gauge the appropriateness of behavior (Campbell, Dunnette, Lawler, & Weick, 1970; James, Hater, Gent, & Bruni, 1978; Jones & James, 1979) and they mediate the relationship between individual and environmental factors and behavior (Payne & Pugh, 1976; Roberts et al., 1978; Schneider, 1983). Mediated relationships are necessarily causal (James & Brett, 1984). Therefore, it should also be possible to use psychological climate perceptions to predict individual behavior.

In summary, issues in the problem of technical obsolescence and the use of CE as a possible ameliorative factor have been delineated. The importance of both environmental and individual level factors in predicting participation in CE and sustained technical performance have been discussed. Interactional psychology is suggested as a framework for conceptualizing previous research findings and guiding future research. Finally, psychological climate perceptions is used as a means of operationalizing the interactional perspective and predicting individual behavior.

Before formally beginning the argument leading to the postulation of the hypotheses in this study, it is necessary to first discuss exactly what is meant by 'obsolescence'. Second, the history and basic ideas of interactional psychology are briefly reviewed. The third section reviews the psychological climate literature as it pertains to this thesis. Fourth, the literature examining the antecedent conditions leading to engineer participation in CE and the impact of CE on performance is presented. Finally, a model driven by the interactionist perspective which integrates the concept of psychological climate and the fragmented obsolescence literature is delineated.

The Problem of Obsolescence

The concept of obsolescence has been defined very broadly in the literature. Mali (1969) presented the most popular and commonly accepted definition of obsolescence. He defined obsolescence as the ratio of the current knowledge possessed by an individual to the current knowledge in their field. Ferdinand (1966) differentiated between three types of obsolescence; professional obsolescence, areal obsolescence and ex officio obsolescence. Professional obsolescence is defined as the ratio between the level of a person's knowledge in their field to the level of available knowledge in that field; areal obsolescence as the ratio of a person's knowledge in their specialty to the available knowledge in that specialty; and ex officio obsolescence as the ratio of an individual's knowledge to the body of knowledge relevant to the specific tasks carried out by the individual.

These definitions are too global to be useful. Further, they do not directly address the central issue in obsolescence: individual performance. Measuring ratios of individual and existing knowledge states does not address this issue for individual jobs or future roles.. Technical obsolescence should be measured in terms of performance. Several theorists have taken this tack, and defined obsolescence in terms of individual level performance (Burak & Pati, 1970; Dubin, 1972a; Kaufman, 1974a; Shearer & Steger, 1975). Kaufman defined obsolescence as an inability to maintain current or future work roles. Shearer & Steger (1975) stated that individuals are obsolescent to the extent they are unable to apply the knowledge, methods and technologies that are considered important by the members of their profession. Dubin (1972a) and Burak and Pati (1970) defined obsolescence as a reduction of efficiency that occurs over time. Similarly, in this paper, obsolescence is defined as poor performance. This position is consistent with previous research (Kaufman, 1974a; Shearer & Steger, 1975) and is the best available definition of the construct.

Interactional Psychology

The interactionist position arose from a number of theorists who postulated the need to assess both environmental and individual characteristics to accurately predict behavior (Kantor, 1924; Lewin, 1935, 1936, 1938, 1951; Koffka, 1935; Murray, 1938; Ekehammer, 1974). The interactionist perspective has become popular because of the perceived inadequacy of both purely situationist and personalogist (centralist) positions (e.g. Bowers, 1973; Mischel, 1973). While this framework has been available to researchers in the behavioral sciences for some time, it has only recently received attention from industrial and organizational psychologists (Schneider, 1980, 1983; Terborg, 1981).

The major conceptual underpinnings of interactional psychology were described by Terborg (1981) who stated interactional psychology is "...an approach to the study and explanation of behavior that emphasizes a continuous and multidirectional interaction between person and situational characteristics" (p. 569). Another formulation of the interactional position was given by Bowers (1973) "...situations are as much a function of the person as the person's behavior is a function of the situation" (p. 327). As is the case with most perspectives, the exact formulation of the interactionist position varies from theorist to theorist. However, the basic idea of multiple causes of behavior, including the consideration of environmental factors, individual factors, and their interactions, remains constant across interactional approaches.

There is a major weakness in the interactionist position. It provides no typology of situations that specifies relevant individual and environmental factors in a given situation and how those factors interact in that situation. Terborg (1981) and Schneider (1983) describe five possible types of interactions and interpretations that are implied by each. The decision to include or exclude an environmental or individual difference factor in a given study, and the type of interaction to postulate in that study, can only be based on the findings of previous research and existing theory, often outside interactional psychology. Thus, while the interactional perspective provides a realistic and flexible approach to the study of behavior, its lack of specificity limits its utility for hypothesis generation.

A major strength of the interactionist approach is that it provides a framework for summarizing the results of past research and suggesting directions for future inquiry. It is in this capacity that interactional psychology will be utilized in this thesis. An interactional approach will be used to organize the obsolescence literature and derive the major components of the proposed model.

Psychological Climate

In recent years there has been a proliferation of reviews of climate research, and another will not be attempted here (see James & Jones, 1974; Campbell et al., 1970; Schneider, 1975; Jones & James, 1979; Naylor et al., 1980; Schneider, 1980). However, a brief review of issues in climate research relevant to this study is presented.

There have been a number of controversies in the climate literature which need to be addressed. First, climate perceptions are not objective measures of the environment (Lawler, Hall, & Oldham, 1974; James & Jones, 1976; James, et al., 1978). Since psychological processes are important in the formation of climate perceptions (Johnston, 1974; Kerr & Schriesheim, 1974; Schuler, 1975; Naylor et al., 1980; Vannoy, 1965), such perceptions are not directly related to structural characteristics (Schneider, 1983; Porter & Lawler, 1965; Berger & Cummings, 1979).

Second, climate perceptions are not evaluative-affective measures such as attitude or satisfaction (Joyce & Slocum, 1979; Lafollette & Sims, 1975; Newman, 1975, 1977). Third, there has been a good deal of controversy regarding the problems of aggregation in climate measures (James & Jones, 1974; Roberts et al., 1978; Jones & James, 1979; James, 1982). The present research examines individual level perceptions and responses. Thus, there is no need to aggregate (Schneider, 1975; James, et al., 1978; James, 1982).

There is a fair amount of agreement that psychological climate perceptions are a result of both situational and individual characteristics (James & Jones, 1974; Lawler et al., 1974; James & Jones, 1976; Jones & James, 1979; Weick, 1979; Schneider, 1980; Schneider & Reichers, 1983). The objective situational characteristics that are considered salient by the individual (to a particular class of behaviors) are processed by the individual (Jones & James, 1979). To the extent the individual is proactive in processing environmental cues, psychological climate scores will reflect individual as well as environmental factors (Schneider, 1975; Mahoney, 1977; James, et al., 1978; Johnston, 1974; Kerr & Schriesheim, 1974; Schuler, 1975; Vannoy, 1965; Hackman & Oldham, 1975).

Another relevant aspect of the climate research is the role climate perceptions play in the behavior of individuals. These perceptions are used by the individual to order or make sense of the environment, predict outcomes, and gauge the appropriateness of various behaviors (Campbell, et al., 1970; Ittelson, Proshansky, Rivlin & Winkel, 1974; James & Jones, 1974; Mahoney, 1977; Schneider, 1975; Jones & James, 1979). In short, psychological climate perceptions are believed to mediate the relationship between environmental characteristics and behavior (Johnston, 1974; Lawler et al., 1974; Hackman & Oldham, 1975; Payne & Pugh, 1976; Roberts et al., 1978; Schneider, 1983). Further, the existence of multiple climates within any organization (both across levels and across situations) allows for the prediction of specific behaviors (Schneider, 1983).

The Obsolescence Literature

There exists a wide-spread assumption that participation in CE (taking graduate, college or in-house courses; attending seminars or professional conventions; reading technical journals, etc.) will abate technical obsolescence (Landis, 1969; Dubin, 1972a; Kaufman, 1974a; Sanders, 1974). This assumption is shared by many working engineers (Landis, 1969; Kaufman, 1974a). Nevertheless, only 40-50% of working engineers participate in any continuing education activities (Rubin & Morgan, 1967; Kaufman, 1974a). Those who are most likely to become obsolescent are the least likely to participate in challenging (graduate level) CE, which engineers believe to be the most effective means of keeping up-to-date (Kaufman, 1975). In a study with counseling professionals, Emener, Rusch, & Spector (1983) found no relationship between perceived training needs or knowledge adequacy and willingness to attend in-house training courses.

An important question is, what factors are keeping engineers from participating in CE? There have been a number of studies which have examined environmental factors and individual characteristics that may influence engineer participation in CE.

Environmental Factors. Previous research has examined a number of environmental factors which are believed to impact engineer participation in CE. First, those environmental factors which are believed to discourage engineer participation in CE are examined, followed by those factors believed to encourage participation.

The job tasks carried out by many engineers are formatted, repetitive and boring (Kaufman, 1974a). Few engineering jobs require the engineer to utilize a full range of skills and abilities (Mali, 1969). For example engineers spend up to 50% of their time doing tasks which should be handled by technicians (Ritti, 1971b; Kaufman, 1974a) or doing routine paper work (Machine Design, 1964). The work of the engineer is often further constrained by market demands and the accomplishment of immediately required production tasks (Ritti, 1968; Conner & Scott, 1974) which require the engineer to work 50-70 hours a week. From this perspective, participation in CE would take additional time away from family and friends (Machine Design, 1964; Landis, 1969: Kaufman, 1974a). Thus, the nature of many engineers' jobs do not allow them to keep abreast of current developments in their fields and since work already takes up so much of their time, engineers are unwilling to participate in CE during non-working hours.

Another major environmental factor which prevents more engineers from participating in CE is the attitude/behavior of the engineer's immediate supervisor. The engineering supervisor most likely functions in an organizational environment which is focused on the accomplishment of immediate goals (Landis, 1969; Kaufman, 1974a). Long term goals, such as participation in CE and continued technical currency are viewed as secondary priorities, or actual hindrances to production. Anectodal evidence suggests that although supervisors do not overtly discourage participation in CE, it is clear to engineers that their supervisors do not want to lose production time to course taking or reading activities (Landis, 1969; Kaufman, 1974a; Falk, 1974). Kaufman (1975) noted that only 6.6% of engineers who participated in CE did so because they felt their supervisors expected it and only one-half of all engineers felt their organization rewarded participation in CE (Kaufman, 1974a).

Understanding supervisor attitudes should be extremely important in predicting engineer participation in CE. In many organizations, the immediate supervisor has a strong influence on the dispersal of tangible rewards such as promotions, pay raises, job assignments, etc. The supervisor is also in control of a number of social rewards available to the engineer. Porter (1971) stated rewards play an important role in engineer participation in CE. Path goal theory (House & Mitchell, 1974), behavioral learning theory (Thorndike, 1932), valence, instrumentality, and expectancy (VIE) theory (Lawler, 1971, 1973), and the leadership/exchange work of Vecchio (1979) all suggest that overt rewards can strongly influence the behavior of subordinates. The vertical dyad linkage (VDL; Organ, 1974; Dansereau, Graen, & Haga, 1975) and other social exchange literatures (Nord, 1969; Marcus & House, 1973) suggest that social cues even in the absence of overt rewards and punishments can influence subordinate behavior. Given that supervisors do not wish their subordinates to participate in CE (take courses, seminars, training programs, etc.) during working hours, it is unlikely that they would dispense either tangible or social rewards for this behavior. Given that supervisors do not want engineers to participate in CE during working hours, and engineers do not want to sacrifice additional time away from family and friends to participate in CE, it is unlikely engineers will engage in this behavior in the absence of tangible and/or social rewards. It is also likely that the supervisor is seen as a successful individual and is a powerful role model for the subordinate engnineer (House, 1968). Discouragement of participation in CE by a powerful role model is likely to further decrease the probability engineers will participate in CE.

There are a number of other environmental factors which may encourage the engineer to participate in CE. First, engineers may perceive that upper level management encourages engineer participation in CE (Landis, 1969; Kaufman, 1974a). The work of Landis (1969) and Kaufman (1974a) also suggests that engineers are aware of the difference in upper level management and supervisor attitudes toward engineer participation in CE.

Second, due to the widespread concern for obsolescence and observations of the consequences of obsolescence for fellow engineers, the engineer may feel compelled to participate in CE regardless of inhibiting factors. Obsolescent engineers often find themselves doing more drafting and paper work than their more up-to-date colleagues (Kaufman, 1974a). There is also a tendency to give the more interesting and challenging job assignments to technically current engineers and it is often the best technically performing engineers who are promoted into management (Brown, Grant, & Patton, 1981). Therefore, the engineer may acquire a predisposition to participate in CE stemming from career and personal concerns.

A final environmental factor which may encourage the engineer to maintain technical currency would be adherence to professional norms and affiliations (Porter, Lawler, & Hackman, 1975). The engineer's work group could share a core of professional concerns and standards. Informal norms could evolve around high quality work and maintaining technical currency.

Individual Characteristics. Most of the work on individual differences factors and CE has place engineers along a continuum from those with technical orientations to those with managerial orientations. Engineers with technical orientations exhibit interests, values abilities and career patterns similar to those of research scientists (Shepherd, 1961; Ritti, 1971a; Kerr, Von Glinow, & Schriesheim, 1977; McKelvey & Sekaran, 1977; Mossholder, Dewhirst, & Arvey, 1981). Engineers with managerial orientations tend to exhibit patterns of interests, values, abilities and career patterns similar to those of business managers (Webster et al., 1956; Dunnette, et al., 1964; Bailyn & Schein, 1980; Kozlowski & Hults, 1984). Engineers with technical orientations are more likely to choose to work in R&D settings, while those with a managerial orientation are more likely to work in a staff setting (Dunnette et al., 1964; Taylor, 1979).

Recent theory has suggested individuals are differentially attracted and selected into work contexts consistent with their own values, career orientations and interests (Schneider, 1975; 1980). Further, socialization processes tend to imbue newcomers with interpretations and response tendencies similar to incumbents in a setting. This results in work contexts that are characterized not only by the objective environmental and organizational features, but also the characteristics of the individuals in the setting (Kozlowski & Hults, 1986). Therefore, even though values, career orientations and intersts are individual level variables, many work settings are characterized by a narrow set of these individual difference factors (James, 1982).

Research has consistently indicated that the differences between R&D and staff engineers are reflected in a number of values and individual characteristics (Webster et al., 1956; Dunnette, et al., 1964; Bailyn & Schein, 1980). Individuals with a managerial orientation place far greater importance on outcomes such as salary, promotion, having responsibility and authority than their technically-oriented colleagues. They tend to consistently score higher on scales measuring dominance, assertiveness and sociability, and lower on scales measuring the desire to make technical contributions to their field (Dunnette et al., 1964). Evidence also suggests that those favoring the managerial aspects of their work are less intelligent (overall) and have less engineering ability than those oriented toward the technical aspects of their work.

Engineers tend to be oriented toward the organization they work for rather than their profession (Kerr et al., 1977). Engineers feel that the judgment of their immediate supervisor should count most heavily in their performance evaluations (Wilensky, 1964; Perrucci, Lebold, & Howland, 1966). Further, most engineers (both those with technical and managerial orientations) aspire to management (Ritti, 1968). Thus, their motivation to maintain technical currency over time is reduced.

The CE-Performance Relationship

It is generally assumed that participation in CE will abate technical obsolescence and result in high performance throughout an engineer's career (Machine Design, 1964; Dubin, 1972a, 1972b; Sanders, 1974; Kaufman, 1974a). However, the relationship between CE and performance has remained largely unexamined.

In the literature that specifically examines the CE-performance relationship, Kaufman (1978) found a significant and positive correlation (r = .43) between participation in graduate level courses and rated job performance for R&D engineers. Graduate level courses did not have a significant impact on the performance of applied development or manufacturing engineers. In-house courses did not significantly affect the performance of R&D, applied development or manufacturing engineers. This pattern of relationships was consistent throughout the 14 years over which the data were collected.

The results are particularly disturbing as they imply that CE effects are highly specific in their influence on long-term job performance and that there is no impact of CE on applied development or production (staff) engineers. These results run counter to the perceptions and assumptions of practicing enginers. Given the anectdotal evidence, one would expect to find a robust and consistent effect of participation in CE on performance.

In summary, it appears that there are a number of factors that influence engineer participation in CE. These include environmental factors such as job complexity, time involved in job tasks, supervisory attitudes toward updating, upper level management attitudes toward updating, consequences of obsolescence for peers, and professional norms; and individual factors such as interests, values, career aspirations, and abilities. The participation in CE-performance relationship appears to be moderated by engineering function (Kaufman, 1978).

This Study

This study attempts to delineate the factors relevant to engineer participation in CE and assess the impact of that participation in engineer performance. The model illustrated in Figure 1 describes the

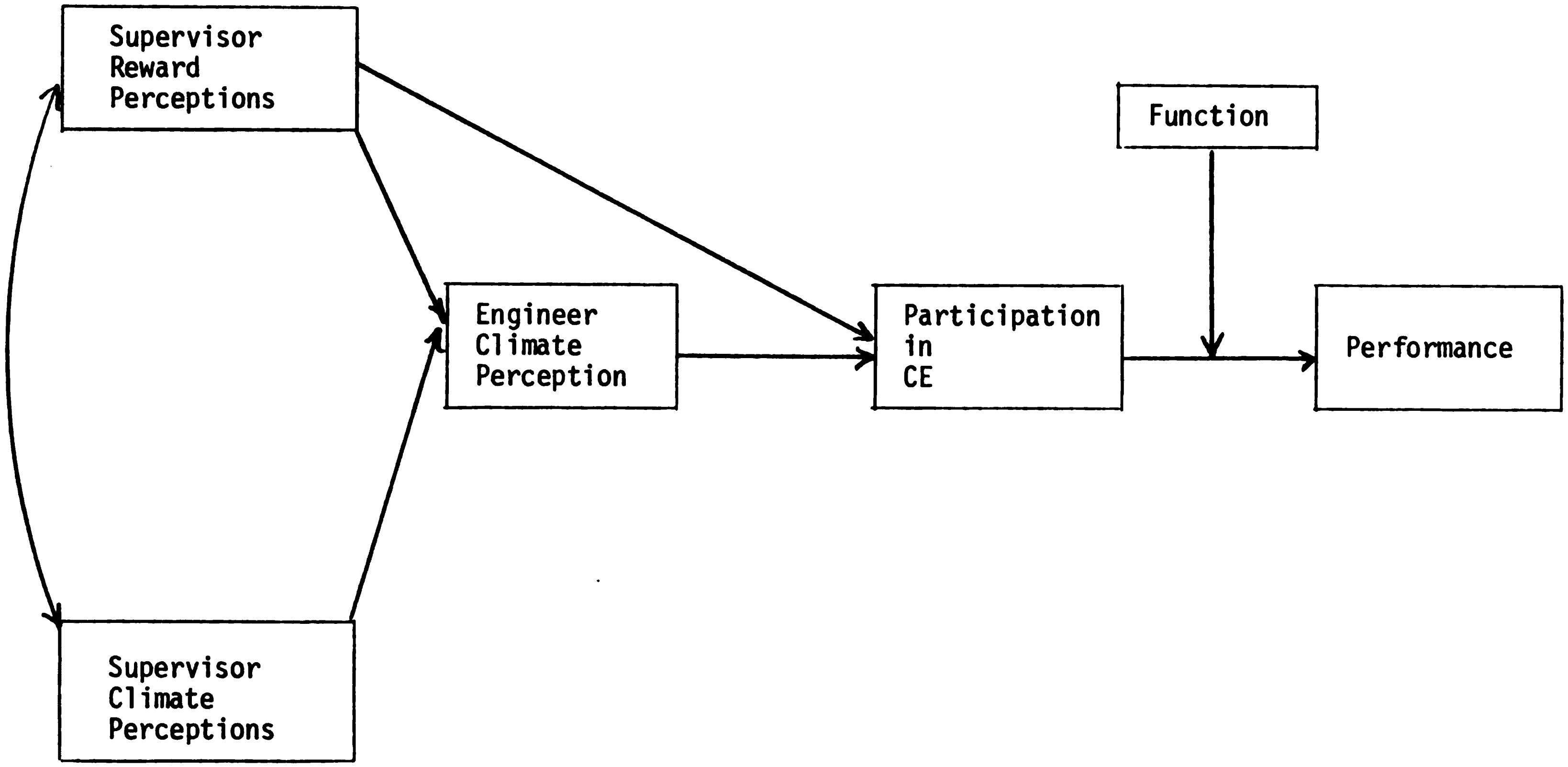

Figure 1. The proposed model.

basic processes leading to engineer participation in CE. It is hypothesized that two factors have a major impact on engineer participation in CE, engineer perceptions of the climate for participation in CE and supervisor perceptions of the organizational reward structure for participation in CE. Climate perceptions are the result of an interaction between salient individual and environmental factors, and mediate the relationship between these factors and behavior (James et al., 1978). Thus, it should be possible to use climate perceptions to predict participation in CE. Supervisor perceptions of the organizational reward structure probably influence their behavior (at least with respect to the dispersal of rewards). Because of the salience of rewards (both tangible and social) in the environment, and the influence supervisors have in the dispersal of rewards, supervisor perceptions of the organizational reward structure for participation in CE should also directly impact engineer participation in CE.

The model also delineates the roles of two important environmental factors in the formation of engineer climate perceptions; supervisor perceptions of the climate and organizational reward structure for participation in CE. Supervisor behavior, like engineer behavior, should be influenced by their perceptions. Through their behavior, they communicate these beliefs to their subordinate engineers. Because of the salience of their role on the subunit, supervisor behavior should influence engineer attitudes. Thus, there should be a relationship between supervisor attitudes and engineer attitudes. With respect to the model, supervisor perceptions of the climate for participation in CE should influence engineer climate perceptions. Further, because of the importance of rewards in the subunit environment, supervisor perceptions of the organizational reward structure for participation in CE should impact engineer climate perceptions.

Finally, as the work of Kaufman (1978) suggested, the CE-performance relationship is expected to be moderated by engineer function.

Factors Directly Impacting Engineer Participation in CE. The central thrust of this study addresses the link between engineer perceptions of the climate for participation in CE and actual participation. Several climates may exist in an organization influencing different behaviors (Schneider, 1983). There are a number of features relevant to the climate for participation in CE that potentially impact engineer participation. For example, if engineers perceive the organization favors innovation and technical currency, they should be more likely to participate in CE. By acting in a manner congruent with perceived organizational goals, engineers are likely to reduce conflict with superiors and peers, and increase the probability of obtaining desired organizational rewards. Since engineers perceive participation in CE is a good means of maintaining technical currency, it is logical to posit perceptions of the organizational orientation toward technical currency and participation in CE should be positively related.

Perceptions of overt organizational support for participation in CE should also impact engineer participation in CE. If the engineers perceive the organization provides time and financial resources for participation in CE, it is more likely the engineer will participate in CE. As previously noted, engineers often spent 50-70 hours per week engaged in tasks relevant to immediate production requirements and are unwilling to spend additional time away from family and friends to engage in CE (Kaufman, 1974a). This is the most often noted reason by engineers for not participating in CE (Landis, 1969). If the organization provides time for participation in CE on-the-job, CE activities will not interfere with time allocated to be with family and friends. The perception that this barrier to participation in CE has been removed or ameliorated should increase engineer participation in CE.

Engineers also cite high tuition costs as another reason for not participating in CE. If engineers perceive the organization provides financial assistance for participation in CE, another barrier to participation in CE is removed. This too should increase engineer participation in CE.

Other barriers to participation in CE are the problems involved in attending conventions and workshops. First, registration costs for conventions and workshops may be very high. Second, these activities may be located in other parts of the country and attendence could involve a substantial investment in travel costs. Finally, engineer supervisors may not want to lose the engineer for a number of days due to production requirements. If engineers perceive the organization will absorb at least some of these costs, and allow them to be away from their subunits for a time without suffering reprisals from their supervisor, they should be more likely to participate in CE.

Finally, it would seem likely engineers would spend more time reading journals and other engineering literature if the organization provided these resources and allowed time on-the-job for reading them. Again, the time to participate in CE on-the-job, and money allocated by the organization for this activity should be important to engineer participation in CE. The preceding discussion suggests that perceptions of time and money allocated by the organization for participation in CE should have a major influence on actual participation in CE.

Engineer perceptions of the complexity of their job assignments should also have an important impact on actual participation in CE. If engineers perceive their jobs are formatted and repetitious, there would no need for them to participate in CE. Their current level of job related knowledge would be sufficient for them to successfully complete the tasks relevant to their jobs. However, if the engineers perceive their jobs as complex, challenging and varied, they should be more likely to participate in CE. Complex, challenging, tasks that push engineers to the limits of their abilities, should cause them to seek out additional information to complete those tasks. Up-to-date, or at least additional information may provide important clues for completing difficult projects or solving difficult problems.

If engineers must engage in a variety of tasks to complete their projects, they should be more likely to engage in CE. Varied tasks are likely to require knowledge and skills in a number of areas. Some engineers are likely to have training in some of these areas, but not all of them. In order to complete the task successfully, they may have to acquire additional information in those areas they are weak in. Engineers who have training in all the areas required by the tasks may not have a current working knowledge of all the relevant areas. In other words, the engineer may have learned the necessary information to do a task, but have to review the information in order to successfully apply it. Reviewing the information is engaging in a type of CE activity. In the process of doing the review, the engineer may also learn additional information that could add to their breadth and contribute to their overall technical currency.

In addition to these specific climate factors relevant to participation in CE, engineers are likely to also have formed an overall perception of the climate for participation in CE. The specific factors are likely to contribute to the formation of the overall perception of the climate for participation in CE. To the extent engineers perceive the organization fosters growth, creativity, the maintenance of technical currency and innovation, they are likely to participate in CE. To the extent engineers perceive the organization discourages these behaviors, they should be unlikely to participate in CE. This discussion leads to the first hypothesis of this study:

Hypothesis 1. Engineer perceptions of the climate for participation in CE will have a direct impact on engineer participation in CE.

Landis (1969) and Kaufman (1974a) both suggested the most important influence on engineer participation in CE is supervisor behavior. It seems that one of the most important channels through which supervisors can exert influence on subordinates is the dispersal of rewards. It is also likely that supervisors probably dispense rewards to those engineers who behave in a manner congruent with their perceptions of the organizational reward policies. Thus, if supervisors believe the organization intends to reward engineer participation in CE, they are likely to disperse rewards for that behavior. If supervisors do not perceive the organization intends to reward engineers for participation in CE, they will not disperse rewards for that behavior.

As noted in the introduction, supervisors are likely to be able to influence the availability of a wide variety of rewards to subordinate engineers. The rewards may be external to the actual work done by the engineer, such as pay raises and promotions. It is usually the supervisor who recommends subordinates for promotions and pay raises to middle and upper level management. The rewards may also directly impact the work done by the engineer. Supervisors are likely to determine how work is allocated on their subunit. Thus, they determine who gets the most interesting and challenging job assignments. Supervisors also have at their disposal a number of social rewards. They may act in a friendly and cordial manner toward the engineer, or keep him/her at a distance. They can also influence the prestige engineers have in the subunit by allowing them responsibility for projects. Finally, supervisors are likely to influence the scheduling of leisure time and vacations in their subunit. Engineers usually report the little free time they have is very valuable to them. It seems likely that at least some, if not all these rewards will be pertinent to any given engineer. These rewards affect the quality of their life both outside the subunit (pay level, and leisure time) and within the subunit (social relations and job assignments). Thus, it is also hypothesized that:

Hypothesis 2. Supervisor perceptions of the organizational reward structure for participation in CE will be positively related to engineer participation in CE.

__Factors Impacting Engineer Climate Perceptions__. Two factors should influence engineer climate perceptions; supervisor perceptions of the climate and organizational reward structure for participation in CE. Supervisor climate perceptions should be related to engineer climate perceptions. Supervisor climate perceptions should influence their behavior. The way they treat the subject of CE on the subunit level should have an important impact on how engineers perceive the climate for participation in CE. The supervisor is the engineers' most direct contact with management. Thus, the supervisor must be seen, to some extent, to represent the desires of management. The supervisors' behavior probably influences engineer perceptions of the organizational orientation toward innovation and creativity. If the supervisor rewards these behaviors, it is likely engineers will perceive the organization supports them.

Further, since supervisors are largely responsible for work scheduling, they should influence how much time engineers are given to participate in CE. Again, engineers are likely to perceive supervisor behavior as indicative of an organizatonal orientation. Supervisors are also likely to have some influence on the availability of some organizational resources to engineers for participation in CE. If supervisors make it difficult for engineers to obtain these resources, it is likely engineers will perceive a climate unfavorable to participation in CE. It is also likely engineers would require the approval of their immediate supervisor before they could take time off work to attend in-house courses, conventions, workshops, and professional society meetings. If they can easily obtain this permission, it should indicate to engineers the organization favors participation in CE. Finally, the supervisor can encourage engineers to participate in CE in their performance reviews. This should also impact engineer perceptions of the climate for participation in CE.

It is very difficult to measure and accurately summarize the influences of these supervisor behaviors on engineers. It would seem to be far more efficient to obtain a measure of predispositions or intentions to behave and the intended effects of these predispositions on engineers. This predisposition to behave can be tapped through psychological climate perceptions (Campbell, et al., 1970; Ittelson, et al., 1974; James & Jones, 1974; Mahoney, 1977; Roberts et al., 1978; Jones & James, 1979; Schneider, 1983). Therefore, it is further hypothesized that:

Hypothesis 3. Supervisor perceptions of the climate for engineer participation in CE will be positively related to engineer perceptions of the climate for participation in CE.

The dispersal of rewards (both tangible and social) is likely to be a salient feature in the subunit environment. Environmental factors play an important role in the formation of climate perceptions (Jones & James, 1979). The dispersal of tangible rewards external to the engineers' projects (e.g. pay raises, promotions etc.) are likely to influence engineer perceptions of the organizational policy toward innovation and technical currency. If the engineers perceive they will be rewarded for participation in CE, they will be more likely to perceive the organization wants their engineers to be current and be able to apply up-to-date methods to projects. These perceptions are likely to also communicate to the engineer that the nearest representative of management, their immediate supervisor, also supports participation in CE. It is also likely that these perceptions will lead to an overall positive perception of the climate for participation in CE.

The dispersal of rewards that directly affect the tasks engineers engage in (e.g. work assignments) are also likely to influence engineer perceptions of the organizational policy and support for participation in CE. If the most interesting and challenging job assignments are given to engineers who participate in CE, engineers are likely to perceive a) the organization encourages participation in CE; b) the organization wants up-to-date methods applied to complex projects; c) their supervisor believes the most up-to-date engineers should work on complex job assignments and d) their supervisor perceives those engineers who participate in CE are the most up-to-date. Again, these perceptions are likely to contribute to a positive overall perception of the climate for participation in CE.

If social rewards on the subunit level are made available to the engineer for participation in CE, this is likely to communicate to the engineer that their supervisor and peers support participation in CE. If the engineers who engage in CE enjoy good relations with their supervisor and peers (holding personality traits constant) this would indicate that the supervisor and peers support or approve of participation in CE. The supervisor may also provide engineers who participate in CE with increased responsibility such as overseeing the completion of a project. This should increase the engineers' prestige on the subunit. Supervisor support for participation in CE also indirectly implies an organizational orientation toward technical currency and innovation. The supervisor is a member of management and is often perceived to represent the desires of management to the engineer (Landis, 1969). Thus, given the salience of tangible and social rewards as factors in engineers' environment, it is hypothesized that:

Hypothesis 4. Supervisor perceptions of the organizational reward structure for updating will be positively related to engineer updating climate perceptions.

The CE-Performance Relationship. The final link in the model addresses the CE-performance relationship. The training literature suggests we can teach people what we wish them to know (Wexley & Latham, 1981) yet fails to demonstrate the impact of the training back on-the-job (Wexley, 1984). The increase in a knowledge, skill or ability in training is a change in an individual level factor. Holding the environment constant, and given a positive increment in an individual level factor, performance should increase. It appears, however, that the training the engineers receive is often not reflected back on the job in improved performance ratings. From an interactional perspective, one would suspect an environmental factor to be inhibiting the expression of the improved individual KSA's on-the-job in the form of higher performance ratings. A key environmental factor for successful transfer of training is supervisor support for the change in behavior (Leifer & Wenston, 1980; Michalack, 1981; Mosel, 1957; House, 1968). The supervisor must (a) positively evaluate the KSA's learned in training and (b) not negatively evaluate the process of engaging in the training.

Many staff engineers spend 50-70 hours a week involved in tasks fulfilling immediate production requirements and doing paper work (Ritti, 1968; Machine Design, 1964). The jobs of many staff engineers are repetitious, formatted and boring (Kaufman, 1974a). The focus in their subunits is on immediate production. Anything that interferes with production (such as participation in CE during working hours) is likely to be negatively evaluated by supervisors. Learning new skills for a job which does not require them is unlikely to cause supervisors to improve performance ratings. Thus, the KSA's learned in training may not be positively evaluated by the supervisor and the act of participating in training is likely to be negatively evaluated by the supervisor. Participation in CE should have a zero or even negative relationship with the performance of staff engineers.

The work of R&D engineers would seem to necessitate their participation in some type of CE throughout the course of their career. Their work involves taking the state-of-the-art technology in any given area and reconfiguring it in some way to meet new performance criteria. Thus, they must not only be up-to-date, they must be able to utilize the latest technological advances to solve new problems. Thus, the relationship between CE and performance should be positive for R&D engineers. This discussion leads to the last hypothesis of this study.

Hypothesis 5. The CE-performance relationship will be moderated by engineering function (R&D vs. staff).

It would seem likely that the effects of CE on performance ratings should occur over time. It will take engineers time to assimilate the information acquired in the CE. After assimilation, there will probably be another time delay before the information will be used on-the-job. Weitz (1966) found a postitive relationship between task difficulty and the amount of time needed for transfer of training. Finally, it will take supervisors time to notice the change in behavior and adjust their assesment of the engineers (Fleishman, 1955). Fleishman (1955) also states it is important to allow sufficient time between the training and the collection of the criterion data to verify that the training had a long-term effect on behavior. Therefore, it would seem the best investigations of the linkage between participation in CE and performance should be longitudinal in nature.

METHOD

Sample

The data were part of a larger study examining antecedents of engineering performance. Engineers (n=140) and their supervisors (n=104) were drawn from seven organizations. The engineers were primarily engaged in R&D (n = 59) and staff (n = 86) functions. They had a mean age of 41.45 years (SD = 10.56), and a mean of 17.79 (SD = 10.03) years of engineering experience. The mean age of the supervisors was 45.97 years (SD = 7.48). They had a mean of 21.30 (SD = 7.42) years of engineering experience, and a mean of 10.69 (SD = 7.47) years of supervisory experience.

The engineers in this sample were employed in six organizations and five divisions of a seventh organization. The range of activities across the organizations was diverse. They were primarily engaged in (by organization): 1) heavy farm equipment manufacture; 2) railroad transportation; 3) floor covering and chemical production; 4) glass and chemical production; 5) office products and computer manufacture; 6) aerospace research; and 7) small appliance manufacture, large appliance manufacture, aerospace electronics, information systems, and nuclear turbines.

The data were obtained in two collections. In the first, supervisor and engineer perceptions of the climate for participation in CE and actual engineer participation in CE were measured. Also obtained in the first data collection were supervisor perceptions of the organizational reward structure for participation in CE and a supervisor report of their subunit function (R&D or staff). In the second, performance ratings for subordinate engineers were obtained. The two data collections occurred approximately one year apart.

Measures

Several of the measurement instruments used in this study were comprised of multiple dimensions. This reflects the complexity of many of the constructs examined in this study. It is not possible to test causal models comprised of multidimensional variables. Therefore, composites were formed to test the model. The procedure for forming each composite is described separately for each measure.

Specific processes involving the individual dimensions of each construct were expected to impact the relationships among the variables in the model. Therefore, for each hypothesis, the relationships among the individual dimensions for the relevant constructs are examined. Then, to examine the adequacy of the model, the composite measures are used in a path analysis. The results section follows this pattern.

Engineer and Supervisor Perceptions of the Climate for Participation in CE.

Engineers and their supervisors responded in one section of the questionnaire to sixty-two items which assessed perceptions of factors facilitating engineer participation in CE in the engineers' working environment (the Work Description Questionnaire for Engineers (WDQE), Farr, Dubin, Enscore, Kozlowski, & Cleveland, 1983). The seven scales of the instrument are (Kozlowski & Hults, 1986):

1. information exchange (the extent engineers and supervisors in

the subunit discuss technical problems and engineers are allowed to participate in technical decision making; engineers, alpha=.79, supervisors, alpha=.81)

2. innovation policy (the extent to which the organization is perceived to emphasize technical excellence and currency; engineers, alpha=.74, supervisors, alpha=.69)

3. updating support (time and money) for participation in CE (the extent the organization provides time and money for engineer participation in CE; engineers, alpha=.77, supervisors, alpha=.64)

4. supervisor support (the extent the supervisor provides career counseling for engineers and opportunitites for professional growth and development; engineers, alpha=.82, supervisors, alpha=.68)

5. job assignments (the extent to which engineer job assignments are in state-of-the art fields, require system and concept development, and stretch the engineers' abilities; engineers, alpha=.77, supervisors, alpha=.80)

6. minimal pressure (the extent to which engineers in the organization need to work overtime to get their jobs done; engineers, alpha=.74, supervisors, alpha=.56)

7. overall updating climate (the extent the organization fosters personal and professional growth, technical creativity and innovation and high technical performance; engineers, alpha=.90, supervisors, alpha=.83)

Appendix A contains a complete listing of the scales. Table 1 displays the scale score intercorrelations for engineers and Table 2 dsiplays the scale score intercorrelations for supervisors.

Table 1

Engineer Climate Scale Intercorrelations

Climate Scales	Intercorrelations							
	1	2	3	4	5	6	7	8
1. Information Exchange	.79							
2. Innovation Policy	.45	.74						
3. Updating Support	.43	.59	.77					
4. Supervisor Support	.54	.58	.65	.82				
5. Job Assignments	.51	.64	.58	.58	.77			
6. Minimal Pressure	.25	.30	.46	.24	.45	.74		
7. Overall Updating Climate	.57	.81	.72	.72	.71	.43	.90	
8. Composite Climate Measure	.69	.82	.83	.83	.81	.44	.93	.90

Note. Scale reliabilities appear in the diagonal. All correlations significant at $p < .01$, one-tailed.

$N = 140$.

Table 2

Supervisor Climate Scale Intercorrelations

Climate Scales	Intercorrelations							
	1	2	3	4	5	6	7	8
1. Information Exchange	.81							
2. Innovation Policy	.38	.69						
3. Updating Support	.50	.42	.64					
4. Supervisor Support	.48	.53	.53	.68				
5. Job Assignments	.47	.55	.37	.36	.80			
6. Minimal Pressure	.23	.15[a]	.41	.09[a]	.35	.56		
7. Overall Updating Climate	.64	.65	.58	.64	.58	.27	.83	
8. Composite Climate Measure	.73	.75	.74	.76	.73	.34	.89	.85

Note. Scale reliabilities appear in the diagonal. All correlations significant at $p < .01$, one-tailed.

[a] $p < .05$, one-tailed.

$N = 104$.

As can be seen in Tables 1 and 2, with the exception of scale 6 (work pressure) the scale intercorrelations are all fairly high. This is because all of the scales measure different facets of a single domain. The scales were summed to provide a composite measure of the climate for participation in CE to be used in testing the model. The first five and seventh scales were included in the composite (engineers, alpha=.90; supervisors, alpha=.85). The sixth scale (work pressure) was deleted from the composite because of its poor reliability (for supervisors), low correlations with the other factors in the scale, its lack of external parallelism, and the fact that its inclusion lowered the alpha of the composite.

Supervisor Perceptions of the Organizational Reward Structure for Maintaining Technical Currency. In another part of the questionnaire, supervisors responded to 31 items which assessed the probability engineers would receive various rewards if they were up-to-date. Supervisors also responded to the same 31 items noting the probability that their subordinate engineers would receive the various rewards if they remained the same technically. To get a measure of the rewards given to engineers for remaining up-to-date it would seem to be necessary to control for the rewards engineers would receive if they do not maintain technical currency. To address this problem the following procedure was used. First, a correlation matrix of the supervisor responses to the items measuring the probability of engineers obtaining various rewards if they remained up-to-date was computed. Then, supervisor responses to the 31 items measuring the probability of engineers receiving various rewards for remaining the same technically were partialed from the correlation matrix for being up-to-date. A principle factors analysis using a varimax rotation (PACKAGE, Hunter, Cohen, & Nichols, 1982) was performed on the residual matrix. A principle factors analysis using a varimax rotation was also performed on the zero-order matrix of supervisor responses to the items measuring the probability engineers would receive various rewards for remaining up-to-date. Varimax rotations were used to emphasize the distinctiveness among the dimensions comprising the construct. The two factor solutions were nearly identical. It was decided to retain the factor solution for the zero-order matrix. Partialing items from a correlation matrix removes unknown portions of variance and the meaning of remaining solution becomes problematic.

The varimax rotation yielded four factors. These factors were:

1. external rewards (rewards given to engineers external to their jobs such as pay, promotions, and job security; alpha=.82)
2. internal rewards (rewards intrinsic to the engineers' job such as complex job assignments and the opportunity to be creative on-the-job; alpha=.85)
3. social/professional rewards (rewards such as getting along with ones supervisor, having responsibility, prestige and opportunities to engage in professional activities; alpha=.76)
4. leisure rewards (time off the job to be with friends and family; alpha=.89)

Appendix B contains a complete listing of the factors. Table 3 displays the scale score intercorrelations.

With the exception of scale 4 (leisure rewards) the scale

Table 3

Reward Scale Intercorrelations

Reward Scales	Intercorrelations 1	2	3	4	5
1. External Rewards	.82				
2. Internal Rewards	.58**	.85			
3. Social Rewards	.61**	.55**	.76		
4. Leisure Rewards	-.09	-.12	-.15	.89	
5. Composite Reward Measure	.92**	.81**	.79**	-.13	.75

Note. Reliabilities appear in the diagonal.

*$p < .05$. **$p < .01$, one-tailed.

$N = 104$.

intercorrelations for this measure are also fairly high. The scales were summed to provide a composite measure of supervisor reward perceptions to be used in testing the model. The first three scales were included in the composite (alpha=.75). The leisure reward scale was omitted because of its poor correlations with the other scales, poor external parallelism, and the fact that its inclusion reduced the reliability of the composite.

Performance. Engineer supervisors provided performance ratings on nine-point behaviorally anchored rating scales. These scales were developed for the specific purpose of assessing engineer performance (Farr, Enscore, Dubin, Cleveland, & Kozlowski, 1983). The 13 scales measured the following facets of engineer performance (Kozlowski & Farr, 1986):

1. technical performance (i.e., scientific and technical knowledge, problem recognition and definition, development of alternative solutions and evaluation of alternative solutions; alpha=.90)
2. administrative skills (i.e., oral and written technical communication, gathering of technical information, organization and planning, implementation of problem solutions, and responding to change; alpha=.88)
3. updating orientation (i.e., professional activities, continuing education activities, work assignments sought, and technical interest and curiosity; alpha=.78).

The three scales were summed to create a composite performance measure (alpha=.87). Appendix C contains a complete listing of the scales. Table 4 displays the scale score intercorrelations.

Participation in CE. The engineers were asked to list the various technical courses, seminars, training programs, professional activities and other activities that they engaged in during the past year for the expressed purpose of improving technical knowledge, skill or job performance. For each activity, they indicated how many hours they spent engaged in that activity and whether it was technical or nontechnical in nature. Technical and nontechnical CE activities were coded separately. These two types of CE activities represent different behaviors with different intended consequences. Technical CE activities involve taking classes which should be related to the technical aspects of the tasks the engineers engage in. Nontechnical CE activities usually involve taking management classes in anticipation of or in preparation for a career move into management. Hours engaged in technical and nontechnical CE were also summed to form the composite variable total participation in CE activities. Appendix D contains the response format used in this portion of the questionnaire. Table 5 displays the frequency distribution of the CE measures.

The CE measures were comprised primarily of external courses (usually at a local college), in-house courses, professional society courses, convention attendence, and reading journal articles and technical manuals. It is not reasonable to expect these disparate of activities to covary in a rational or consistent manner across indviduals. Therefore, internal consistency reliabilities are uninterpretable for these variables. Test-retest reliabilities assume enginers are consistent in the way they participate in CE across time,

Table 4

Performance Scale Intercorrelations

Performance Scales	Intercorrelations 1	2	3	4
1. Technical Performance	.90			
2. Administrative Skills	.83	.88		
3. Updating Orientation	.67	.61	.78	
4. Composite Performance Measure	.93	.92	.84	.87

Note. Reliabilities appear in the diagonal. All correlations significant at $p < .01$, one-tailed.

$N = 149$.

or the time periods over which the data are collected represent complete cycles of engineer participation in CE. These are very tenuous assumptions. Test-retest reliabilities are also uninterpretable for these variables.

Since reliability measures are not computable for these variables, their distributional properties were examined. As can be seen in Table 5, 38 of the 149 (26%) engineers did not engage in any CE activities. Further, there is a substantial amount of variance in engineer participation in CE during the previous year. Very few engineers (36 or 24%) engaged in any nontechnical CE activities. This creates a distributional problem for the nontechnical CE variable. It was included in the analyses, but caution must be used in interpreting the results.

Analyses

The first four hypotheses of this study were examined using a zero-order correlation. The fifth hypothesis posited the relationship between participation in CE and performance would be moderated by engineering function. This hypothesis was tested using a heirarchical multiple regression procedure. Performance was the dependent variable. Total engineer participation in CE was entered into the prediction equation first, followed by engineering function, and finally the multiplicative term (Participation in CE X Function). An $\underline{F}$-test of the incremental $\underline{R}^2$ for the multiplicative term was used to determine the significance of the moderator.

The appropriateness of the overall model was tested using path analytic procedures. Path coefficients were obtained using PACKAGE

Table 5

Frequency Distributions of the CE Measures

No. of Hours	Type of CE Activity		
	Total	Technical	Nontechnical
0	38	49	113
1-10	18	17	6
11-20	14	16	3
21-30	7	7	6
31-40	11	14	6
41-50	9	8	4
51-60	3	1	3
61-70	4	4	2
71-80	10	8	0
81-90	6	5	1
91-100	5	4	0
101-110	4	2	0
111-120	4	3	2
121-160	6	4	1
161-200	4	4	0
201-240	3	2	1
241-280	2	0	0
> 280	1	1	0
Mean	52.06	40.29	11.77
Standard Deviation	69.55	62.16	31.72

_N_ = 144

(Hunter et al., 1982). For the pupose of testing the path model, the moderator variable was computed using the deviation score $(X-\bar{X})(Y-\bar{Y})$. This was done to reduce the correlation between the moderator (XY) and the main effects X and Y. PACKAGE will not accept a model with several highly correlated predictors. The rational for this procedure follows (John E. Hunter, personal communication, January 11, 1986). X is perfectly correlated with $(X-\bar{X})$, and Y is perfectly correlated with $(Y-\bar{Y})$. However, a normally distributed X is almost perfectly uncorrelated with $(X-\bar{X})^2$. Similarly, $(X-\bar{X})(Y-\bar{Y})$ is not highly correlated with either a normally distributed X or Y.

The goodness of fit of the model was tested using Pedhazer's (1982) W statistic. This statistic allows the researcher to determine if there is a significant difference between the correlation matrix obtained from the just-specified model and the correlation matrix obtained by the over-specified model. The just specified model contains all possible linkages between the variables and always perfectly reproduces the correlation matrix. In the over specified model, linkages are deleted, and those that remain are hypothesized to have causal properties. The over specified model may or may not accurately reproduce the correlation matrix, contingent on the relative importance of the retained and deleted paths. If there is not a significant difference between the correlation matrix reproduced by the just specified model and the over specified model, the over specified model adequately describes the nature of the relationships among the variables in the model.

RESULTS

The first section of the results describes the findings of the hypotheses testing procedures. These results are presented on a hypothesis by hypothesis basis in the order they were described in the introduction (1-5). Second, the results obtained from testing the path model are presented. Several hypotheses in the study were not supported. The model was found not to adequately describe the nature of the relationships among the variables. Therefore, several exploratory analyses were run. The findings of these analyses are presented in the third section of the results.

In the exploratory analyses, first the relationships among the summary variables in the model that had not been tested in the hypotheses were examined. Several interesting relationships were found, and these were examined on a dimension by dimension basis. Unfortunately, none of the variables in the model were significantly related to engineer participation in CE (except performance). Thus, in the third section of the exploratory analyses, a number of individual difference and environmental variables expected to impact engineer participation in CE were examined.

In the final section of the results, the major findings of the study are summarized.

The Hypotheses

Hypothesis 1. The first hypothesis posited a positive relationship between engineer perceptions of the climate for participation in CE and engineer participation in CE. This hypothesis was not supported ($r = .03$, $p > .30$, $n = 140$). See Table 6 for a complete breakdown of the correlations between the engineer climate scale scores and participation in CE.

As can be seen in Table 6, none of the engineer climate scales were significantly related to participation in CE. It appears that engineer perceptions of the climate for participation in CE do not impact their participation in CE. It is particularly surprising to note that engineer perceptions of time and money allocated by the organization for participation in CE (Scale 3) did not significantly relate to engineer participation in CE. This result is in direct conflict with engineer self-reports and anectdotal evidence (Kaufman, 1974a).

Hypothesis 2. The second hypothesis of this thesis posited a positive relationship between supervisor perceptions of the organizational reward structure for remaining up-to-date and engineer participation in CE. This hypothesis was not supported ($r = -.01$, $p > .40$, $n = 140$). As can be seen in Table 7 there is almost no relationship between any facet of supervisor reward perceptions and engineer participation in CE.

Only leisure rewards had a significant relationship with participation in technical ($r = .14$, $p < .05$, $n = 140$) and total ($r = .15$, $p < .05$, $n = 140$) CE. It appears that engineers will participate in CE given the opportunity to get some time off. However, given the

Table 6

Correlations of Engineer Climate Responses with Participation in CE

Climate Scales	Participation in CE		
	Technical	Nontechnical	Total
Information Exchange	-.01	-.04	-.03
Innovation Policy	.09	-.08	.05
Updating Support	0.00	-.07	-.03
Supervisor Support	.12	-.07	.08
Job Assignments	.10	-.09	.05
Minimal Pressure	.05	.07	.08
Overall Updating Climate	.04	-.04	.02
Composite Climate Measure	.07	-.08	.03

$^{*}p < .05$. $^{**}p < .01$, one-tailed.

$N = 140$.

Table 7

Correlations of Supervisor Reward Responses with Engineer Participation in CE

	Reward Scales				
Participation in CE	External Rewards	Internal Rewards	Social Rewards	Leisure Rewards	Composite Reward Measure
Technical	-.01	-.01	-.03	.14*	-.01
Nontechnical	.00	-.01	.01	.05	.00
Total	-.01	.01	-.02	.15*	-.01

*p < .05, one-tailed.

N = 140.

size of the correlations and size of the sample in this study, this effect may be attributable to sampling error (Schmidt & Hunter, 1978).

Hypothesis 3. The third hypothesis posited a positive relationship between supervisor perceptions of the climate for participation in CE and engineer perceptions of the climate for participation in CE. This hypothesis was supported (r = .24, p < .01, n = 140). See Table 8 for a complete breakdown of the correlations between engineer and supervisor climate scales.

Most of the diagonal elements (same dimension, supervisor and subordinate ratings of the same job) are significant. However, if these correlations are viewed as measures of the interrater (supervisor and subordinate) reliability of the climate scales, they are very low. Other studies have also found differences between supervisor and subordinate perceptions along various dimensions including the tasks that need to be done to perform a job (O'Reilly, 1973), and subordinate performance (Schmitt, Noe, Merrit, & Fitzgerald, 1984).

Supervisor and subordinate perceptions of the climate for information exchange (Scale 1) were not significantly correlated. Supervisor perceptions of the climate for information exchange were generally not correlated with subordinate perceptions of the remaining climate scales. Similarly, subordinate perceptions of the climate for information exchange were generally not correlated with supervisor perceptions of the other climate scales. Supervisor and subordinate engineer perceptions of the overall climate were also not significantly related. Supervisor perceptions of the overall climate were generally unrelated to subordinate perceptions of the separate climate scales.

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Table 8

Correlations of Engineer and Supervisor Climate Responses

Supervisor Climate Scales	Engineer Climate Scales							
	1	2	3	4	5	6	7	8
1. Information Exchange	.01	.02	.04	.00	.05	.00	.02	.03
2. Innovation Policy	.17*	.21**	.16*	.11	.20**	.06	.18*	.21**
3. Updating Support	.09	.17*	.41**	.20**	.19*	.19*	.24**	.28**
4. Supervisor Support	.07	.11	.20**	.18*	.05	-.04	.13	.16*
5. Job Assignments	.11	.23**	.20**	.15*	.40**	.20**	.18*	.25**
6. Minimal Pressure	.02	.11	.28**	.03	.18*	.48**	.12	.16*
7. Overall Updating Climate	.10	.13	.10	.03	.17*	-.02	.08	.12
8. Composite Climate Measure	.12	.20**	.25**	.15*	.25**	.10	.19*	.24**

*_p_ < .05. **_p_ < .01, one-tailed.

_N_ = 140.

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Similarly, subordinate perceptions of the overall climate scale were generally unrelated to supervisor perceptions of the first six climate scales. In most cases, the overall climate scales were significantly related to the other climate scales within raters (supervisors and subordinates) (See Tables 1 and 2). Thus, while there is a *significant* amount of agreement between supervisor and subordinate perceptions on the composite scale, the effect is not as substantial or consistent as expected. This further underscores the lack of agreement between supervisor and subordinate perceptions of the climate for engineer participation in CE.

Hypothesis 4. The fourth hypothesis posited a positive relationship between supervisor perceptions of the reward structure for remaining technically up to date and engineer perceptions of the climate for participation in CE. This hypothesis was not supported (r = .09, $p > .10$, n = 140). As can be seen in Table 9 there is almost no relationship between supervisor perceptions of the rewards for being technically up-to-date and engineer perceptions of the climate for participation in CE.

This suggests that either the supervisors are not communicating the organizational policy to the engineers or supervisors are not acting in a manner consistent with their perceptions of the organizational reward structure. There was a significant correlation between supervisor perceptions of the availability of leisure rewards and work pressure (r = .23, $p < .01$, n = 140). This suggests that the greater the work pressure on the subunit the greater the likelihood engineers will be rewarded with time off if they participate in CE. There was also a

Table 9

Correlations of Supervisor Reward with Engineer Climate Responses

	Reward Scales				
Climate Scales	External Rewards	Internal Rewards	Social Rewards	Leisure Rewards	Composite Reward Measure
Information Exchange	.04	.07	.11	.05	.07
Innovation Policy	.03	.12	.12	-.02	.08
Updating Support	.00	.01	-.03	.09	.00
Supervisor Support	.06	.12	.11	-.01	.10
Job Assignments	.07	.15*	.09	.10	.11
Minimal Pressure	-.05	-.08	-.07	.23**	-.07
Overall Updating Climate	.08	.12	.04	.02	.10
Composite Climate Measure	.06	.12	.08	.05	.09

$^{*}p < .05$. $^{**}p < .01$, one-tailed.

$N = 140$.

significant correlation between engineer perceptions of job complexity and supervisor perceptions of rewards intrinsic to engineers' work for participation in CE (r = .15, p < .05, n = 140). This suggests that the more complex the engineers' job assignment, the greater the possibility they will be rewarded with complex job assignments for participating in CE.

Hypothesis 5. The fifth hypothesis of this study posited that the relationship between engineer participation in CE and performance will be moderated by engineering function. This hypothesis was not supported (F = .39, p > .30, d.f. = 3,141). The incremental r^2 for the moderator was .002. To explore this hypothesis further, regressions were run using the other three performance dimensions as the dependent variable and the type of participation in CE to which they were logically most related as a predictor and a factor in the multiplicative term. Participation in non-technical CE was used in the equation predicting administrative skills and technical CE in the equation predicting technical performance and updating orientation. The moderator variable was not significant in any of these equations. See Table 10 for the R^2's, incremental r^2's, and F's of the variables in the moderator analyses.

The Model

A path analysis was performed to test the overall fit of the model. Although given the bivariate results, little was expected, the model and path coefficients are illustrated in Figure 2. As can be seen in Figure 2 several of the path coefficients are zero or near zero. The χ^2 of the test for the difference between the correlation matrix

Table 10

Moderator Analysis by Performance Facet

Dependent Variable	Independent Variable	R^2	R^2 Change	F	df
Composite Performance Measure	Total CE	.04	.04	6.56*	1,143
	Engineering Function	.15	.10	17.25**	2,142
	Total CE x Function	.15	.002	.39	3,141
Administrative Performance	Nontechnical CE	.01	.01	2.09	1,143
	Engineering Function	.09	.08	11.07**	2,142
	Nontechnical CE x Function	.09	.0003	.05	3,141
Technical Performance	Technical CE	.03	.03	4.09*	1,143
	Engineering Functions	.09	.06	9.70**	2,142
	Technical CE x Function	.09	.0007	.11	1,141
Updating Orientation	Technical CE	.11	.11	17.64**	1,143
	Engineering Function	.23	.12	21.64**	2,142
	Technical CE x Function	.23	.002	.33	1,141

*$p < .05$. **$p < .01$.

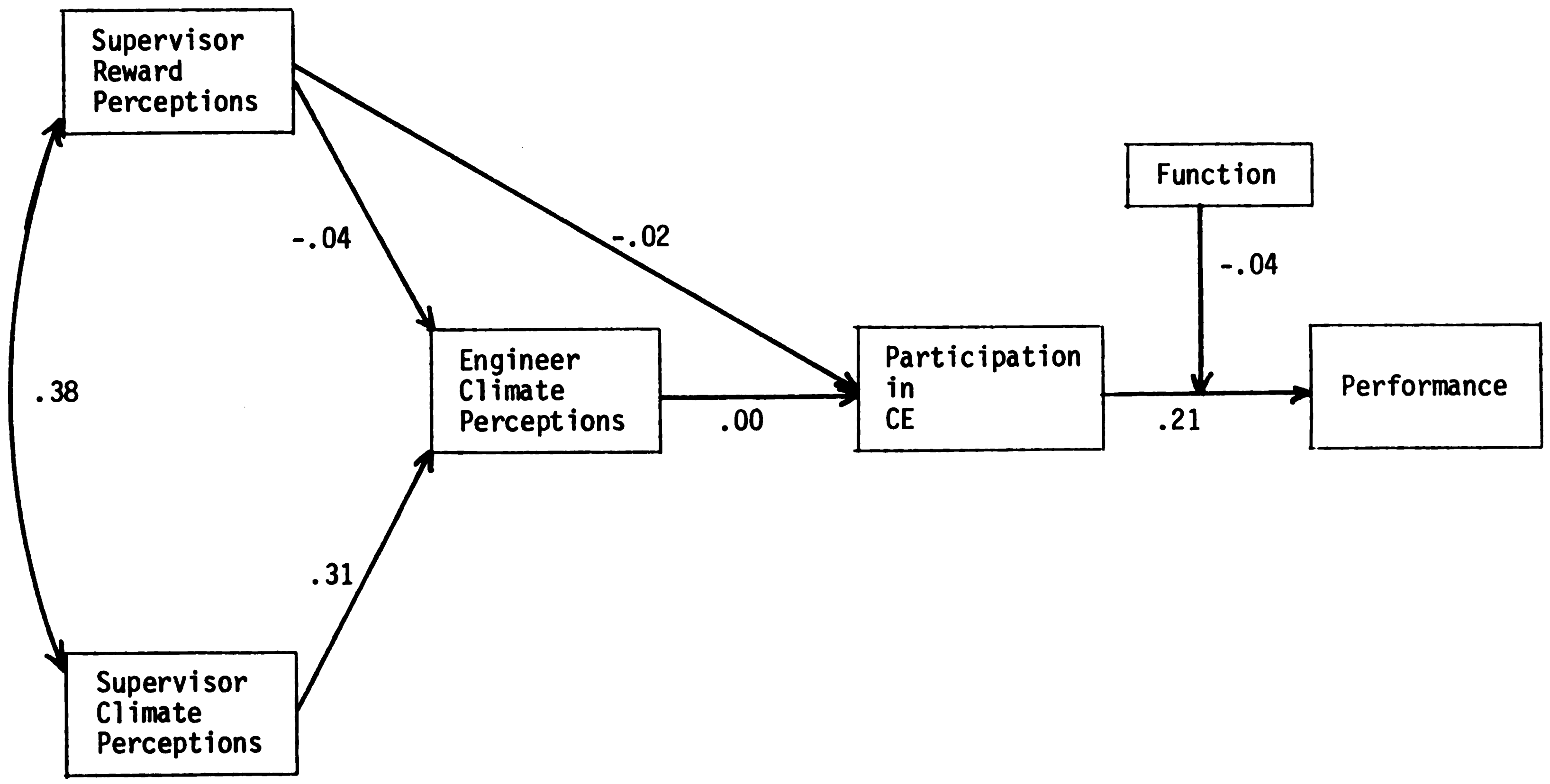

Figure 2. Path coefficients of the proposed model.

produced by the overidentified path model and the just specified path model was significant ($\underline{X}^2$=32.64, $\underline{p}$<.005, $\underline{df}$=14). The model does not fit the data.

Exploratory Analyses

Since the model did not fit the data and a number of the hypotheses of this theses were not supported, a follow-up analysis was performed in an attempt to discover the nature of the linkages between the variables. A correlation matrix was generated for the major summary variables (supervisor reward perceptions, supervisor climate perceptions, engineer climate perceptions, engineer participation in CE, and performance) in the proposed model and is displayed in Table 11.

As can be seen in Table 11, supervisor perceptions of the organizational reward structure were significantly related to supervisor updating climate perceptions ($\underline{r}$ = .38, $\underline{p}$ < .01, $\underline{n}$ = 104). This suggests that supervisor perceptions of the reward structure for participation in CE are consistent with their perceptions of the climate for engineer participation in CE. Supervisors who tend to perceive the climate for participation is high also tend to believe engineers will be rewarded for maintaining technical currency. This effect may be partially attributable to method variance.

Both supervisor and engineer climate perceptions were significantly related to engineer performance (engineers, $\underline{r}$ = .33, $\underline{p}$ < .01, $\underline{n}$ = 140; supervisors, $\underline{r}$ = .32, $\underline{p}$ < .01, $\underline{n}$ = 140). See Tables 12 and 13 for a complete breakdown of the correlations between engineer and supervisor climate perceptions and the performance facets.

Table 11

Correlations of the Major Composite Variables

Composite Variables	Intercorrelations 1	2	3	4	5
1. Supervisor Composite Reward Measure	1.00				
2. Supervisor Composite Climate Measure	.38[a]**	1.00			
3. Engineer Composite Climate Measure	.09	.24**	1.00		
4. Total CE	-.01	.02	.03	1.00	
5. Composite Performance Measure	.01	.32**	.33**	.23**	1.00

*$p < .05$. **$p < .01$, one-tailed.

$N = 140$. $N^a = 104$.

Table 12

Correlations of Engineer Climate Responses with Rated Performance

	Performance Scales			
Climate Scales	Technical Performance	Administrative Skills	Updating Orientation	Composite Performance Measure
Information Exchange	.19*	.24**	.20**	.24**
Innovation Policy	.17*	.19**	.26**	.23**
Updating Support	.30**	.33**	.25**	.33**
Supervisor Support	.24**	.23**	.30**	.29**
Job Assignments	.27**	.20**	.26**	.27**
Minimal Pressure	.26**	.22**	.12	.23**
Overall Updating Climate	.20**	.26**	.20**	.25**
Composite Climate Measure	.28**	.30**	.30**	.33**

*$p < .05$. **$p < .01$, one-tailed.

$N = 140$.

Table 13

Correlations of Supervisor Climate Responses with Engineer Performance

	Performance Scales			
Climate Scales	Technical Performance	Administrative Skills	Updating Orientation	Composite Performance Measure
Information Exchange	.08	.08	-.05	.04
Innovation Policy	.26**	.22**	.23**	.27**
Updating Support	.25**	.26**	.28**	.30**
Supervisor Support	.20**	.15*	.22**	.21**
Job Assignments	.37**	.27**	.23**	.33**
Minimal Pressure	.22**	.21**	.16*	.23**
Overall Updating Climate	.26**	.20**	.24**	.26**
Composite Climate Measure	.32**	.27**	.26**	.32**

*p < .05. **p < .01, one-tailed.

N = 140.

For supervisors, this effect may be partially due to method variance. However, supervisors responded to the climate scales and performance scales one year apart, and the response formats on the two instruments were different. This effect is fairly consistent across all climate scales and all performance facets for both supervisors and subordinates. Supervisor perceptions of information exchange are not related to any performance facets. Engineer perceptions of work pressure are not related to supervisor ratings of updating orientation.

It was also found that participation in CE was significantly related to performance ($\underline{r} = .23$, $\underline{p} < .01$, $\underline{n} = 140$). See Table 14. It appears that participation in technical CE has the greatest impact on overall performance ($\underline{r} = .23$, $\underline{p} < .01$, $\underline{n} = 140$). The correlation between overall participation in CE and supervisor ratings of updating orientation was also significant ($\underline{r} = .31$, $\underline{p} < .01$, $\underline{n} = 140$). This suggests that supervisors are sensitive to the amount of CE their engineers engage in. Ratings of participation in nontechnical CE were not significantly related to ratings of administrative skills ($\underline{r} = .11$, $\underline{p} > .05$, $\underline{n} = 140$). Participation in technical CE was significantly related to ratings of technical performance ($\underline{r} = .19$, $\underline{p} < .05$, $\underline{n} = 140$).

These results lead to the trimmed model of supervisor and subordinate updating climate perceptions, supervisor perceptions of the organizational reward structure, participation in CE and performance illustrated in Figure 3. Since the model is based on an exploratory analysis, it may only serve to further delineate the nature of the data and guide future research. It cannot be considered a confirmatory

Table 14

Correlations of Engineer Participation in CE with Performance

Performance Scales	Participation in CE		
	Technical	Nontechnical	Total
Technical Performance	.19*	.04	.18*
Administrative Skills	.08	.11	.13
Updating Orientation	.36**	-.02	.31**
Composite Performance Measure	.23**	.05	.23**

*p < .05. **p < .01, one-tailed.

N = 140.

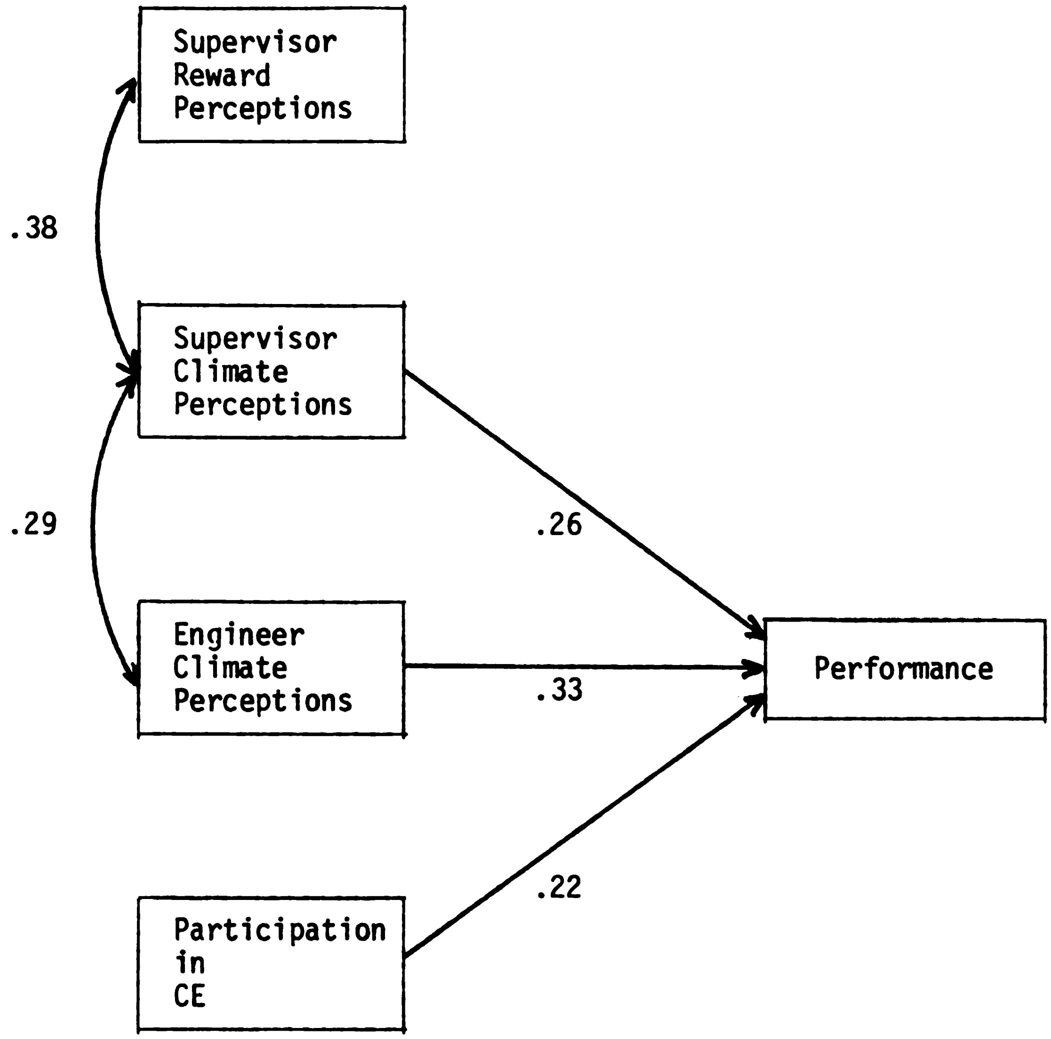

Figure 3. The trimmed model.

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model. The beta weights for the model are included in Figure 3.

Supervisor climate perceptions, engineer climate perceptions and participation in CE all made significant independent contributions to the prediction of engineer performance. These three variables account for 22% of the variance in engineer performance ratings. Supervisor and engineer perceptions of the climate contribute almost completely independent portions of variance to the prediction of engineer performance.

A major focus of this study was to identify the factors involved in engineer participation in CE and describe the interrelations among those factors. None of the hypotheses for factors affecting engineer participation in CE were supported. Only the performance variables had a significant relationship with engineer participation in CE. In a further attempt to discover factors that are related to engineer participation in CE, additional exploratory analyses were run.

A correlation matrix was generated for the CE variables (technical, nontechnical and total participation) and a number of variables that were believed to have some relationship with participation in CE. For example, age and organizational tenure have generally been believed to be positively related to technical obsolescence and negatively related to participation in CE (Kaufman, 1974). It seems likely that those who are involved in R&D functions should be more likely to engage in CE activities than those engaged in staff functions. Similarly, it should be more likely that those working in technologically advanced industries (e.g. aero space) should be more likely to engage in CE behavior than those engaged in less technologically advanced industries (e.g

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(e.g. floor covering). It would also seem likely that those who expect to remain in technical work should do more technical updating, while those who intend to move into management should participate in more nontechnical CE activities. The major findings of this exploratory analysis are displayed in Table 15.

As can be seen in Table 15, the variables with the strongest correlations with total participation in CE were years with the company ($r = -.30$, $p < .01$, $n = 128$) and age ($r = -.27$, $p < .01$, $n = 128$). As engineers become older, or spend more time with their company, they are less likely to participate in CE. Engineering function was not significantly related to participation in technical CE ($r = -.13$, $p > .05$, $n = 128$), but was significantly related to participation in nontechnical in CE ($r = -.20$, $p < .05$, $n = 128$). It also appears that engineers in technically more advanced companies tend to participate in technical CE ($r = -.20$, $p < .05$, $n = 128$). Companies were ranked for technological sophistication by the experimenter and his major advisor based on their knowledge of existing definitions of technological complexity and the advisor's experience with the companies.

Career expectations and preferences were also related to participation in CE. An expectation of being in a managerial function in five years is positively related to participating in nontechnical CE ($r = .22$, $p < .05$, $n = 128$). Preferring to be in a managerial function in five years was also significantly related to participation in non-technical CE ($r = .21$, $p < .05$, $n = 128$). An expectation or preference to be in a technical function in five years was not significantly related to participation in technical CE ($r = -.11$, $p >$

Table 15

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Table 15

Correlation Results of the Exploratory Variables with Participation in CE

Exploratory Variables	Participation in CE Technical	 Nontechnical	 Total
Years in the Organization	-.25**	-.15*	-.30**
Age	-.21**	-.17*	-.27**
Company[a]	-.20*	.03	-.16*
Function[b]	.13	-.20*	.02
Positional[c] Expectation: 5 Years	-.11	.22**	.00
Position &[c] Preference: 5 Years	-.12	.21**	.00

*$p < .05$. **$p < .01$, one-tailed.

$N = 128$.

[a] Coded 1 (high technology) to 7 (low technology).

[b] Coded 1 (staff), 2 (R & D).

[c] Coded 1 (technical position), 2 (nontechnical position).

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.10, n = 128). It appears engineers will participate in CE to correct deficits in managerial KSA's, but not to maintain technical currency.

Multiple regressions were run to determine how much variance in participation in CE could be predicted using the variables identified in this portion of the analysis. Using technical, non-technical and total participation in CE as the dependent variables, the variables in Table 15 were entered into the regression equations. See Table 16 for the results of the regressions.

Only years in the organization and technical orientation of the company made a significant contribution to the prediction in participation in technical CE. The R was .31, accounting for 10% of the variance in participation in technical CE. Expected position in five years, engineering function and age made a significant contribution to the prediction of participation in non-technical CE. The multiple R was .34, which accounts for 12% of the variance in participation in nontechnical CE. Years in organization was the only significant predictor of total participation in CE. The R was .30 accounting for 9% of the variance in total participation in CE. Thus, it appears we were still largely unable to predict engineer participation in CE.

Summary

In summary, engineer perceptions of the updating climate were not significantly related to engineer participation in CE. Supervisor perceptions of the climate were significantly related to engineer climate perceptions. Supervisor perceptions of the organizational reward structure were not related to engineer participation in CE or

Table 16

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Table 16

Results of Regression Analyses Predicting Engineer Participation in CE

Dependent Variable	Independent Variables	Beta Weight	R^2
Technical CE	Years in the Organization	-.24	
	Company	-.19	.10
Nontechnical CE	Career Expectation: 5 Years	.19	
	Function	-.21	
	Age	-.17	$.11^2$
Total CE	Years in the Organization	.30	.09

Note. All beta weights significant at $p < .05$.

$N = 128$.

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engineer climate perceptions. The relationship between participation in CE and performance was significant but not moderated by function. Engineer and supervisor climate perceptions, and engineer participation in CE were related to performance. Supervisor reward structure perceptions and climate perceptions were also significantly related. Years in an organization and age were the best predictors of participation in CE. Career preferences and expectations and the technical orientation of the engineers' company were also related to participation in CE. These variables accounted for about 10 percent of the variance in engineer participation in CE.

DISCUSSION

The first section of the discussion focuses on the major findings of the hypothesis testing procedures. Second, the results of the exploratory analyses are discussed. Third, the limitations of the study are described. Finaly, directions for future research are outlined.

The Hypotheses

The hypotheses are discussed in the same order that they were presented in the introduction and results sections. While several hypotheses of this study were not supported, the results are still instructive. The implications of these results are discussed on a hypothesis by hypothesis basis.

Engineer Climate Perceptions and Participation in CE. The results of this study indicated that engineer perceptions of the climate for participation in CE had no impact on actual engineer participation in CE. This lack of effect was consistent across all seven climate scales for technical, non-technical and total participation in CE. The scale that should have had the greatest effect on engineer participation in CE, perceptions of time and money allocated by the organization for participation in CE (Scale 3), also had no impact. These time and money factors have previously been cited as central to discussions of engineer participation in CE (Kaufman, 1974; Landis, 1969; Machine

Design, 1964). Several reasons for this lack of relationship are noted in the limitations of the study section.

Supervisor Reward Perceptions and Engineer Participation in CE. Supervisor perceptions of the organizational reward structure for remaining up-to-date also had no influence on engineer participation in CE. It could be that the reward practices of the supervisors are not adequately communicated to the engineers. This is an unlikely explanation of the lack of effect. On most jobs, people know who gets promoted, who gets the best job assignments, who gets pay raises, and why. It may also be that supervisors do not act in accordance with their self-reported beliefs about the organizational reward structure. This also appears to be an unlikely explanation of the lack of effect. It does not seem reasonable to conclude supervisors would believe they should act in a particular manner and then consciously act in an incongruent manner (Ericsson & Simon, 1980). It may be that supervisors have little influence over the dispersal of rewards in the subunit. Thus, their beliefs about how organizational rewards are distributed may have no impact on the actual distribution of those rewards.

A third possibility is that the rewards measured by the reward perception scales are not important to engineers. Even if supervisors communicated their beliefs to engineers, this knowledge may have little impact on engineer behavior. The assumption that pay increases, promotions, increased professional standing, and complex job assignments are important to engineers may be largely contingent on individual differences, or completely erroneous. This possibility is underscored by the small correlation between the leisure reward scale and participation in CE. Engineers may be willing to participate in CE only if that participation allows them to escape from work. This may be a very difficult issue to explore. Stating that one is not interested in more money, promotions, increased professional prestige, etc., but in increased time off may be perceived as socially inappropriate and unprofessional. Engineers may not respond to questions about their value systems accurately.

Supervisor and Engineer Climate Perceptions. There was not a substantial amount of agreement between supervisor and engineer perceptions of the climate for participation in CE. This may be because supervisors operate in a climate geared toward immediate production while engineers have long-term career concerns (Kaufman, 1974). This difference in individual orientations may have caused the discrepancies in engineer and supervisor climate perceptions. Engineers are also aware that their immediate supervisor and upper level management disagree regarding the utility of participation in CE (Landis, 1969). This environmental factor may have also contributed to the differences between supervisor and engineer climate perceptions.

Supervisor Reward and Engineer Climate Perceptions. There was no relationship between supervisor reward and engineer climate perceptions. This may be related to the discrepancy between supervisor and engineer climate perceptions. Different perceptions of the reward structure are likely to lead to different climate perceptions. It may also be that supervisors do not have a substantial input into how rewards are dispersed on the subunit. If this is the case, there is no real mechanism for supervisors to clearly communicate their perceptions of the reward structure to engineers.

The CE-Performance Relationship. Participation in CE had a positive relationship with engineer performance. This effect was not moderated by engineering function as was found by Kaufman (1978). This inconsistency in results may be due to sampling error (Schmidt & Hunter, 1978). It may also be a function of the differences in the time in which the two studies were done. Because of the constantly accelerating changes in technology it may now be perceived that all engineers need to remain up-to-date.

The effect size of the relationship between participation in CE and performance was small. This may be because the organizations in this study typically did not do any sort of needs assessment before instituting a CE program. The typical CE activity for most engineers is participation in a professional society course, in-house training course or taking a course at a local college (Landis, 1969). It is important to target a training course back to the job the trainee is doing to assist in transfer of the training (Wexley & Latham, 1981). Due to the continuous change in technology it may also be necessary for engineers to have a long term plan for remaining up to date. Again, this is typically not the case (Hults & Kozlowski, 1986).

Finally, participation in CE is clearly not the only factor relevant to engineer performance ratings. The identification of other factors relevant to performance and their effects on performance ratings may indicate how reasonable it is to expect a large effect size for participation in CE on performance. If a number of other variables account for a large percent of variance in engineer performance, it may not be reasonable to expect to also find a large effect for participation in CE.

Exploratory Analyses

The most important findings of the exploratory analyses were the positive relationships among engineer and supervisor perceptions of the climate for participation in CE and performance. Several processes that potentially underlie these relationships are discussed in detail. Then, the attempts to predict participation in CE using various individual difference and environmental variables are discussed.

Climate Perceptions and Performance. Engineer perceptions of the climate for participation in CE were positively related to engineer performance ratings. There may be two reasons for this positive relationship. First, it could be that engineers who perceive good intentions on the part of the organization may work harder and thereby receive higher performance ratings. Engineers are aware of the problem of technical obsolescence. They know if they become obsolescent they may be moved into drafting positions with no opportunity for growth or promotion. Some articles suggest that unless engineers have concrete plans for remaining up-to-date they should plan to 'bail out' of engineering (Thompson et al., 1974). The perception that the organization cares about their engineers, supports their efforts to keep up to date, and does not keep them under the constant pressure reported by many engineers, may cause them to give the organization their best effort.

Second, it could be that appropriate climates, those that are supportive of communication, creativity, innovation and technical excellence, actually elicit these behaviors from engineers without their necesarrily participating in CE activities (particularly as they were defined in this study). If these behaviors are critical to engineer performance, this suggests a direct link between climate and performance. Organizations may wish to foster appropriate climates in order to get the most productivity from their engineers.

Supervisor and engineer perceptions of the climate for engineer participation in CE made almost completely independent contributions to the prediction of engineer performance. This is particularly interesting since the supervisors responded to their climate measures as they perceived the scales applied to the jobs of their subordinate engineers. It is possible that in the case of the supervisors the relationship between climate perceptions and performance is due to source method variance. However, supervisors filled out the two instruments one year apart and the instruments have very different response formats and assess different content. The pattern of correlations between the climate scales and performance scales, with the exception of information exchange (Scale 1) are nearly identical for supervisors and subordinates.

These results indicate it may be important that both supervisors and subordinates perceive a positive atmosphere for growth and innovation in order for engineers to be maximally effective. There was minimal agreement between supervisors and subordinates on the climate for participation in CE. As climate perceptions mediate the relationship between the environment, individual difference factors, and behavior, it is likely that differing climate perceptions result in different behavior patterns. Engineer behavior is likely to be the product of individual factors and the behavior patterns of salient members of the environment. Therefore, engineer communication, innovation and growth oriented behavior is the result of the interaction between individual factors and supervisor behavior. This perspective suggests interactions may be additive in nature (Terborg, 1981). It is not surprising that both supervisor and engineer perceptions of the climate make independent contributions to performance.

It is also likely that supervisor reinforcement of innovation and creativity is important for the maintenance of these behaviors. If supervisors do not overtly support this type of behavior, it may still be maintained by other sources of reinforcement in the organization. As Landis (1969) and Kaufman (1974) indicate, engineers are sensitive to upper-level management influences. These influences could also maintain the innovative behavior in the engineers. Thus, it is possible for engineers to continue to engage in these types of behaviors even if they are not overtly rewarded for them by their supervisors. However, it is likely that supervisor behavior is very influential, and their impact on engineer performance is substantial.

Other Variables Affecting Engineer Participation in CE. It was interesting to note that an expectation or preference to be in a managerial position in five years had a significant relationship with participation in nontechnical CE, while an expectation to be in a technical position in five years was not significantly related to participation in technical CE. It appears engineers may participate in CE when they feel they have a deficit in managerial knowlege but not a deficit in technical knowledge. It may also be that engineers do not really believe participation in CE is an important factor in technical career success. These and the other factors that were found to make a significant contribution to the prediction of engineer particpation in CE accounted for at best 12% of the variance in engineer participation in CE. It is still unclear what factors lead to engineer participation in CE.

Limitations of the Study

The major limitations of this study involved the definitions and operationalizations of the CE measures. These factors have been largely ignored in previous research. However, because of their central position in the model, problems with the CE measures potentially affected a number of hypotheses, and subsequently the fit of the model. The limitations of the CE variables as they were defined and measured in this study are discussed in detail below. Any one of these difficulties could have attenuated the results of this study, though it is likely a number of these factors worked in concert to attenuate the results. Further, this study did not adequately measure the individual difference factors hypothesized to impact engineer participation in CE. Finally, this study did not differentiate the relationships among the constructs in the model for different types of engineers (e.g. chemical, electrical, civil, mechanical). Differences across the types of engineers in the sample may have also attenuated the results of this study.

The Participation in CE Measure. Several different types of CE activity were included in this measure. External courses (at local college), in-house courses, professional society courses, journal reading, and convention attendence were all collapsed into technical and nontechnical categories of CE behavior. Then, the number of hours spent in the various activities were summed to form the technical, nontechnical and total CE activities variables. It may not have been reasonable to assume these types of behaviors were parts of a single dimension of CE activities. They are more likely to represent qualitatively different dimensions of the construct of CE activities. Therefore, it is not clear if they are caused by the same factors or if they have similar effects of performance. This may have also attenuated the relationships among climate, reward structure, performance and participation in CE.

The distributions of the CE variables were also skewed with a substantial number of engineers not participating in any CE during the past year. Also, about 11% of the sample participated in much more CE activities than their peers. This accentuates the distributional problems with these variables. Finally, very few engineers participated in any nontechnical CE activities. Any conclusions drawn from analyses using this variable were necessarily tenative.

A second problem with the CE measure was the time period over which both the CE and outcome (performance) data were collected. In this study it was assummed that engineers participated in CE gradually throughout the course of their career. However, engineers may spend a considerable amount of time engaged in CE activities at selected points in their careers, and relatively little time on a continuous basis. The time period over which these cycles of participation and nonparticipation in CE occur is unclear. This is largely because the trigering mechanism for the starting of a cycle has not been identified. It is likely that engineers only participate in CE when they change jobs, their jobs are reclassified or the organization they work for goes through a major technological reconfiguration. This study collected data over a very limited time period (one year), it is just a snapshot. This time period may or may not correspond to a cycle of participation in CE for any given engineer. Because of the number of potential triggering mechanisms for a cycle of CE, it may not be reasonable to assume cycles begin and end simultaneously for engineers in different specialities and/or in different organizations.

This timing factor may have attenuated the climate-participation relationship, the reward structure-participation in CE relationship, and the participation in CE-performance relationship. Any organization may have a positive climate and reward structure for participation in CE. However, engineers in that organization who do not perceive themselves as obsolescent would be unlikely to participate in CE, regardless of the climate or reward structure. When engineers need to participate in CE, the reward and climate factors should facilitate that participation. If there was no need to participate in CE for a group of engineers, there would be no reason to expect a positive relationship between the climate, reward structure and participation in CE in that group. Similarly, if there was no need to participate in CE, there is no reason to expect a positive relationship between performance and participation in CE. The participation in CE would not be job relevant.

This suggests it may be necessary for future research to either sample only from groups of engineers who perceive themselves as being obsolescent, or analyze the data for engineers who percieve themselves as being obsolete and those that do not separately. The two groups probably have different updating needs and should differentially react to updating climates and reward structures. The impact of participation in CE on performance is also likely to be different for the two groups. In the obsolescent group, participaiton in CE should have a positive relationship with performance, in the nonobsolescent group, participation in CE should have a small or zero relationship with performance.

For example, manufacturing hardware is very expensive and rarely replaced. If a company is using the same production machines over time it may not be necessary for production engineers to update. It could be that the old machinery may not be able to use new materials. If a new product is ordered, the engineers would need to discover how to reconfigure the same materials they had been working with previously to fit the new product specifications. If new machinery was installed, which used only recently developed materials, the enginers may have to learn about the new materials. It would then be necessary to participate in CE. As long as the old machinery was in place, it would not be necessary to participate in CE. The same knowledge and skills that allowed engineers to design products that were produced on the old machinery may also allow them to continue to design new products to be made on the old machinery. Only when the old machinery is replaced does the engineer need to update.

Further, it is unclear how much time should elapse between collecting participation in CE and performance data. It is likely to take time for the information learned in the CE course to be applied on-the-job (Weitz, 1966). It is also likely to take time before the supervisor notices the change in job-related behavior (Fleishman, 1955). However, if an engineer has consistently performed well, and the participation in CE is in response to a technological breakthrough or organizational reconfiguration, this may not be an issue. The supervisor would not need to reevaluate that engineer. Finally, criterion data should be collected after a sufficient period of time to be sure the CE activity had a long-term effect on behavior (Fleishman, 1955). Unfortunately, the relative latencies for each of these factors have not been specified. It is unclear if this study collectd data over an appropriate time period.

Another problem with the CE measure was the restricted range of CE activities examined. This study examined only a small set of the possible CE activities engineers can engage in. The primary types of CE activities coded were in-house courses, off site (usually at a local college) courses, professional society courses and other professional activities. Engineers may use a variety of other mechanisms to remain technically current. Recent research has shown job complexity has a positive relationship with the long-term performance of engineers, independent of participation in CE (Hults & Kozlowski, 1986). This suggests that simply by engaging in complex job tasks, engineers may become technically more current. In this study, climate for participation in CE and technical excellence also had a positve relationship with long-term performance. This suggests there may be several other general environmental/work factors utilized by engineers to remain technically current. It may be the relationships among the variables in the model were attenuated because of the unrealistically narrow set of CE activities examined.

A final problem with the participation in CE measure was its specificity in relation to the specificity of the variables used to predict it. Participation in CE is a very restricted set of behaviors, particularly as they were defined in this study. The measures used to predict it were very global. The climate scales measured the climates for information exchange, innovation, participation in CE, job complexity, work pressure, overall climate. The reward structure scales measured the availability of external, internal, social and leisure rewards for remaining technicallly current. However, specific behaviors are probably best predicted using specific measures (Fishbein and Ajzen, 1975). Research has shown attitude-behavior relationships increase dramatically when specific attitudes are used to predict specific behavior (Zalesny, 1986).

Individual Difference Factors. The theoretical perspective used in this study assumed climate perceptions resulted from an interaction between individual and environmental factors. The present research did not assess individual factors relevant to engineer participation in CE. The items in the climate questionnaire were carefully developed by Farr, Dubin et al. (1983). The scales were the result of a very careful factor analysis by Kozlowski and Hults (1986). However, the scales measure primarily the environmental factors which are expected to impact engineer participation in CE. While they are sensitive to individual differences in the processing of the environmental cues, they may not be sensitive to individual differences relevant to engineer participation in CE. Thus, they may not provide an adequate representation of individual factors relevant to participation in CE. The scales may be adequate only for measuring engineer and supervisor perceptions of environmental factors relevant to participation in CE. Individual difference factors should have been measured independently and built into the model.

Differences Across Engineer Functions. It may also be a mistake to lump all engineers into a single category, or make a simple staff-R&D distinction. Engineers are at least as diversified as any group of professionals and studying them generically may be masking important individual differences and differences between engineering groups. There may be different rates of change requiring different amounts of pariticipation in CE across different types of engineers. It may be necessary to break out different types of engineers (e.g. chemical, civil, mechanical, aerospace) and investigate the factors leading to their participation in CE and subsequent performance separately.

Future Research Directions

This discussion leads to four recommendations for future research on engineer participation in CE and subsequent performance. First, CE measures should be more carefully developed and complete. Second, the role of individual differences in engineer participation in CE should be explored in more detail. Third, CE activities should be targeted specifically to the jobs engineers work on. Finally, the role climate plays in engineer performance and possibly other outcomes should be more thoroughly investigated.

Improved CE Measures. The primary suggestion for future research that is indicated by this study is the importance of carefully developing measures of CE activities. First, separate dimensions of CE activities should be separately coded and analyzed. This would allow for the measurement of the internal consistency of the dimensions. This would also allow for investigating the possibility of different dimensions of CE activities having different causal antecedents and differential impacts on performance.

Second, it is important to do research on both antecedent conditions leading to participation in CE and the outcomes of that participation over a much longer time period. This would allow for the identification of the a) cycles of participation in CE for engineers, and b) the triggering mechanisms for these cycles. Longer-term research would also allow researchers to determine how long a time period should pass between collecting participation in CE and performance data. Several issues relevant to this factor were noted in the introduction (latency to transfer, supervisor reassessment of perfomance), but the time periods involved in each factor have not been specified.

Third, it may be necessary to increase the scope of how CE activities are defined. This study and previous research (Hults and Kozlowski, 1986) have suggested that engineers may use a variety of methods for maintaining technical currency. Attempts need to be made to identify these methods. They should then be included in measures of participation in CE. Further, the processes underlying the relationship between these methods and performance should be outlined.

Finally, specific climate and attitude measures should be used to predict the specific dimensions of participation in CE. This would seem to allow for the most variance in participation in CE to be accounted for (Zalesny, 1986).

Individual Differences. Future research should also directly incorporate a number of individual difference factors in models of engineer participation in CE. There is currently little research to assist scientists in identifying the individual difference factors which are relevant to engineer participation in CE. Kaufman (1975) stated that those most in need of CE are the least likely to participate in CE. Similarly, Emener et al. (1983) found no relationship between perceived training needs and willingness to attend in-house training courses. Age also has been consistently found to be negatively correlated with participation in CE (Kaufman, 1974). Two potential individual difference factors that may assist researchers attempting to understand the process of engineer participation in CE are the needs and values and career orientations of engineers.

Needs and Values. Engineer needs and values are a potentially relevant individual difference factor to participation in CE. This study assumed engineers would be motivated to participate in CE by a certain set of rewards. These rewards may not have been important to the engineers in this study. Thus, it may be necessary to reevaluate which variables are seen as potentially motivating to engineers.

There is evidence that suggests engineers have needs and values that are different from those of other professional groups (Kerr et al., 1977). Unfortunately, most surveys of engineer career, interest, and ability patterns have used instruments such as the SVIB (Dunnette, et al., 1964; Webster et al., 1951) which primarily compare engineer interest patterns to those of professionals (though the SVIB has a farmer and carpenter scale) or compared engineers to scientists and managers (McKelvey & Sekaran, 1981). The review of Kerr et al. (1977) suggests it may be necessary to not view engineers as professionals. There are those who state the engineers may possess values, needs, and work attitudes similar to those in 'blue collar' work roles (Strauss, 1963). It may be necessary to examine engineers from this perspective in order to gain a clear understanding of their interests, needs, and desires and the roles these values play in their participation in CE.

Career Orientation. Another relevant individual factor may be the technical or nontechnical career orientation of engineers. Some work has shown that engineers tend to fall into two categories, those with a predisposition toward the technical aspects of their work and those with a managerial orientation (Dunnette et al., 1964). It has not been clearly demonstrated that those with a technical orientation are more likely to participate in CE. This study did not find a significant relationship between technical function and technical position preference and participation in technical CE. There was a significant relationship between nontechnical function and nontechnical career orientation and participation in nontechnical CE. Though this evidence is somewhat sparse, it does suggest that there may be some utility in investigating engineer career patterns and their relationship to participation in CE. It may be the relationship between perceived training needs and participation in CE is more complex than previously believed. For example, only those who perceive a technical knowledge and skill deficit and intend to remain in technically oriented fields may participate in technical CE. Those who intend to move into management may participate only in nontechnical CE. This suggests, contrary to Emener et al., 1980, there may be some relationship between perceived training needs and engineer participation in CE. It simply has not been adequately examined yet.

Targeting CE Activities to Engineer Jobs. Future research should develop CE activities that are directly related to the work engineers are engaged in. The development of these activities should be based on a thorough needs analysis. This should increase he impact of participation in CE on performance. Further, it may be necessary to develop CE activities based on projected training needs. Due to changes in technology, it may be necessary for engineers to have a long-term plan for remaining up-to-date. Further, projected technological reconfigurations by organizations my require engineers to develop long-term plans for remaining current with respect to changing job requirements.

The Effect of Climate on Engineers. Some of the most interesting, and somewhat unexpected findings of this study were the positive relationships among engineer and supervisor climate perceptions and engineer performance. This pattern of relationships suggests climates that are supportive of communication, innovation, technical excellence, and creativity actually elicit these kinds of behaviors, and these behaviors lead to improved performance for engineers. Similarly, in the popular literature, several authors have linked organizational orientation or climate to individual and organizational performance (Kanter, 1983; Peters & Waterman, 1982). Kanter (1983) suggested companies that have positive climates for creativity and innovation promote these behaviors in their employees. Peters and Waterman (1982) suggested companies that foster experimentation, autonomy, product champions, and even a little resource piracy for pet projects, lead their industries in technological breakthroughs, and ultimately, overall performance. This study provides some initial empirical support for these authors' views. However, it is still unclear a) which factors cause these climate perceptions, b) which factors mediate the relationships between the climate perceptions and performance, and c) what roles individual difference factors play in these relationships. Identifying these factors and delineating the relationships among them should lead to a greater understanding of engineer updating and performance.

APPENDICES

Appendix A

Engineer and Supervisor Perceptions of the Climate for Participation in CE

Instructions to Engineers

The following statements are concerned with the nature of your work assignments, the actions and attitudes of your peers and supervisor, the policies of your organization, and other characteristics of the organization which employs you. We are interested in how well you think that each of these statements describes your job, organizaion, supervisor, or peers. Use the scale below to indicate your judgement about each statement. Write the number indicating your judgment in the space to the left of each statement. Please do not omit any statements.

Instructions to Supervisors

The following statements are concerned with the nature of an engineer's work assignments, the actions and attitudes of his peers, the policies of the organization, and other characteristics of the organization which affect the engnieer(s) you supervise. We are interested in how well you think that each of these statements describes the job situation of _your subordinate engineers_. Since there are probably some differences in how well the statements describe the particular job of each engineer you supervise, think of the _typical_ job situation of the group of engineers whom you supervise. (Note that when the "supervision" is used in a statement, this refers to _your_ actions, attitudes, or procedures.) use the scale below to indicate your judgment about each statement. Write the number indicating your judgment to how accurately the statement describes the job situation of your subordinate engineer (and NOT your own job). Please do not omit any statements.

Scale for Both Engineers and Supervisors

1	2	3	4	5	6
a very inaccurate statement	a generally inaccurate statement	a more inaccurate than accurate statement	a more accurate than inaccurate statement	a generally accurate statement	a very accurate statement

Scale 1
Information Exchange

____1. Information exchange is restricted by excessive competition among the engineers in the organization.

____2. Other engineers in the organization prefer to keep new ideas to themselves.

____3. My supervisor does not allow any engineer to understand the total project by withholding pertinent information and discouraging communication among the engineers.

____4. The engineer lacks the authority to make technical decisions about a project.

____5. Peers are willing to act as sounding boards for new ideas.

____6. Peers often react negatively to new technical ideas.

____7. There are open lines of communication between the engineering staff and organization management.

____8. The engineer participates in technical decisions relevant to assignments.

____9. My supervisor elicits ideas from the engineers regarding technical problems.

____10. Peers are able to suggest new approaches to technical problems based upon their own experience.

Scale 2
Innovation Policy

____1. There exists a competitive atmosphere among fellow engineers which maintains pressure toward high levels of job performance.

____2. The organization attempts to be better technically than its competition.

____3. The recruitment practices of the organization bring competent young engineers into the organization.

____4. People in technical disciplines view the organization as an innovator.

____5. Peers are able to provide reliable information about current technical developments.

____6. The organization has a performance appraisal system which ties financial gain to technical competence.

____7. Peers are able to catch logical and analytical errors in designs and ideas.

____8. Work assignments include state-of-the-art technology and advanced instrumentation.

____9. The organization provides its engineers with current technical equipment and facilities.

____10. My supervisor bases salary and promotion recommendations on technical performance.

Scale 3
Updating Support

____1. The organization pays for subscriptions to technical and trade journals for the engineer.

____2. My supervisor encourages the reading of technical journals and trade magazines during working hours.

____3. My job allows some time to explore new, advanced ideas.

____4. All of the engineer's time must be charged to project budgets with no allowance for general technical updating.

____5. The organization does not provide financial support for attending professional meetings.

____6. The engineers have a sense of personal involvement in the organization's future.

____7. Engineers who receive advanced training and degrees receive little formal recognition in the organization.

____8. The organization has a limited training budget for its engineering staff.

____9. My supervisor restricts the participation of the engineers in professional activities to a minimum.

____10. The organization provides limited funds for internal research and development.

____11. Assignments are made in the area of the engineer's personal interest, when possible.

Scale 4
Supervisor Support

____1. My supervisor provides career counseling for the engineer.

____2. My supervisor involves the engineer in establishing performance goals by which the engineer will be evaluated.

____3. My supervisor's performance reviews point out the engineer's strengths and weaknesses and offer suggestions for improvement.

____4. The organization provides career counseling for engineers.

____5. My supervisor matches the engineer's need for professional development with opportunities to attend courses and technical meetings.

____6. My supervisor does not recognize and reward an engineer's efforts to keep technically up-to-date.

____7. My supervisor holds periodic staff meetings to discuss technical problems and developments.

____8. My supervisor encourages engineers to present papers at technical meetings.

Scale 5
Job Assignments

____1. Job assignments are frequently made to a product or area in which little or no technological change is occurring.

____2. Assignments require system and concept development.

____3. Job assignments are challenges which stretch the engineer's technical knowledge to the limit.

____4. The organization is involved in technically stagnant fields.

____5. Engineers are often assigned to non-technical tasks.

____6. Job assignments are frequently repetitious and formatted.

____7. Engineers are not always hired for engineering jobs.

____8. Challenging work is often assigned only to newer engineers.

____9. My supervisor is not technically up-to-date or abreast of recent technical developments.

___10. Fellow engineers discourage attempts to remain technically current.

Scale 6
Minimal Preassure

____1. The organization keeps its engineering staff small, relying on overtime toget the work done.

____2. The job requires extensive overtime.

Scale 7
Overall Updating Climate

____1. There is a discouraging and indifferent attitude toward technological innovation and excellence.

____2. There is little leadership in the organization regarding professional standards.

____3. Personal creativity and growth are stifled by the organization.

____4. Low value is placed on the development of human resources to achieve organizational excellence.

____5. The organization is concerned with the professional growth of its engineers.

____6. There is a limited opportunity for engineers in the organization to use their technical knowledge.

____7. The organization has a progressive atmosphere.

____8. The organization recognizes the technical contributions of its engineeers.

____9. Innovation is enthusiastically received within the organization.

____10. The organization stresses high professional standards.

____11. Organizational rewards are given to those engineers with technical competence.

Appendix B

Supervisor Perceptions of the Organizational Reward Structure for Maintaining Technical Currency

Rewards for Maintaining Technical Currency

Below is a list of items which describe possible rewards or outcomes related to an engineer's job. Some engineering jobs require more up-to-date technical skills than others. Similarly, some organizations reward technical competence more than do other organizations. In the following section, you are asked to judge whether engineers who are more technically current or remaining about the same technically as your engineers are now will affect the chances of them receiving or obtaining each of the outcomes below. Since there are probably some differences in how well the outcomes may apply to particular engineers whom you supervise, think of the *typical* job situation of the group of engineers and not any one specific person or job.

Use the scale below to make your judgments. Place the number indicating your judgment in the space to the left of the outcome.

IF AN ENGINEER BECOMES *MORE* TECHNICALLY UP-TO-DATE DURING THE NEXT YEAR OR TWO, THE CHANCES THAT HE/SHE WILL OBTAIN OR RECEIVE "THIS" OUTCOME (SEE LIST BELOW) IN HIS/HER JOB WILL____________.

-3	-2	-1	0	+1	+2	+3
strongly decrease	moderately decrease	slightly decrease	not change	slightly increase	moderately increase	strongly increase

Example: Read the sample outcome below:

+2 0. opportunity to win distinguished engineering awards for work performed on the job.

A rating of +2 has been written in the space to the left of the outcome. This rating indicates the belief that the chances of obtaining the opportunity to win distinguished engineering awards will moderately increase if engineers become more technically up-to-date.

Read each item below and rate the chances an engineer will have in obtaining the reward or outcome if he/she becomes more technically up-to-date during the next year.

Rewards for Remaining the Same Technically

Below is another listing of the same rewards and outcomes you have just rated. Use the same rating scale to makey your next judgments.

IF AN ENGINEER REMAINS ABOUT THE SAME FOR THE NEXT YEAR OR TWO AS HE/SHE CURRENTLY IS IN TERMS OF TECHNICAL KNOWLEDGE AND SKILL, THE CHANCES THAT HE/SHE WILL OBTAIN OR RECEIVE "THIS" OUTCOME (SEE LIST BELOW) IN HIS/HER JOB WILL ________________.

Example: Read the sample outcome below

-1 0. Opportunity to win distinguished engineering awards for work performed on the job.

A rating of -1 has been written in the space to the left of the outcome. This rating indicates the belief that the chances of obtaining the opportunity to win distinguished science awards will <u>slightly decrease</u> if engineers remain the same as they currently are in terms of technical knowledge and skill.

Read each item and use the scale below to rate the chances an engineer will have in obtaining the reward or outcome if he/she remains about the Same for the next year or two as he/she currently is in terms of technical knowledge and skill.

<u>Note</u>: the scaling is the same for both sets of responses.

Scale 1
Extrinsic Rewards

____1. Less than adequate salary.

____2. Lack of recognition for accomplishment and well-done job

____3. Recognition for accomplishments and technical success.

____4. Opportunity for advancement based on quality of work performance.

____5. Salary and merit increases, based on performance.

____6. Lack of opportunity for advancement.

____7. Failure to reward individuals for well-done job.

____8. Organizational reward for those who maintain and expand technical skils.

____9. Immediate feedback with regard to success of assignment.

___10. Having job security.

___11. Lack of opportunity to grow technically and professionally.

___12. Limited promotional opportunity for those who maintain technical competence.

___13. Feeling of achievement resulting form work assignment.

___14. Being assigned routine and technician-type work.

Scale 2
Internal Rewards

____1. Recognition of the rapid change in technology.

____2. Having assignments in the forefront of technology.

____3. Company reputation for technological leadership and excellence.

____4. Desire for excellence in work assignment.

____5. Opportunity for professional development.

____6. Opportunity to be creative and innovative.

____7. Being assigned challegning work.

____8. Opportunity to publish technical articles and books.

Scale 3
Social/Professional Rewards

____1. Good relations with co-workers (fellow engineers).

____2. Getting along with supervisor.

____3. Opportunity to excercise personal initiative in assignment.

____4. Having major responsibility for a project.

____5. Opportunity to join professional societies, attend professional meetings and present technicl papers.

____6. Availability of technical library.

____7. Seeing how one's assignments fit into the overall project.

Scale 4
Leisure Rewards

____1. Having time for family activities.

____2. Having time for recreational and leisure activities.

Appendix C

Behaviorally Anchored Rating Scales

Technical Performance

Scale 1

Scientific and Technical Knowledge. The possession of fundamental scientific, mathematical, and engineering knowledge necessary for adequate completion of a project or assignment.

Numerical Scale		Examples of Amounts of this Factor
9 8 7	more than an adequate or acceptable typical amount of this factor	-Is considered the technical expert in the department or component of the organization -Uses the latest technical principles, rather than cookbook formulas, to perform tasks -Performs assignments with minimal technical assistance
6 5 4	an adequate or acceptable typical amount of this factor	-Has a good working knowledge of the applicable technology -Has fundamental grasp of engineering principles -Is aware of relevant technology advance
3 2 1	less than an adequate or acceptable typical amount of this factor	-Is unfamiliar with the precise definitions of many technical terms -Often needs technical help from colleagues in order to complete an assignment -Has difficulty understanding basic engineering designs

Specific instances of this individual's work activities related to this factor:____

____

________Numerical Description for this Factor

Scale 2

Evaluation of Alternative Solutions. The use of theoretical, analytical, and empirical methods to determine the likely consequences of alternative solutions.

Numerical Scale		Examples of Performance
9 8 7	more than adequate or acceptable typical performance on this factor	-Selects a solution based upon well-documented and thorough analysis -Quantifies all known pro's and con's associated with the possible consequences of proposed solutions -Quickly finds the strong and weak points of alternatives
6 5 4	adequate or acceptable typical performance on this factor	-Does not prejudge any possible solution before the evaluation data are complete -Evaluation of alternatives is limited to obvious or conventional considerations
3 2 1	less than adequate or acceptable typical performance on this factor	-Sometimes cannot point out the comparative advantages and disadvantages of two alternatives -Occasionally ignores or fails to consider some significant data when evaluating alternative solutions

Specific instances of this individual's work activities related to this factor:____

____

__________Numerical Description for this Factor

Scale 3

<u>Development of Alternative Solutions</u>. The ability to create several technically feasible solutions to a problem.

Numerical Scale		Examples of Performance
9 8 7	more than adequate or acceptable typical performance on this factor	-Appropriately looks for better ways to do a job -Presents to management several alternate solutions to a technical problem and justifies the recommended alternative -Creates imaginative solutions to long-term problems
6 5 4	adequate or acceptable typical performance on this factor	-Sometimes offers several solutions to a technical problem for management to choose from -Develops another approach to a problem only when the current approach fails -Occasionally requires prompting by the supervisor to look for more than one possible solution to a problem
3 2 1	less than adequate or acceptable typical performance on this factor	-Doesn't consider challenging the "status quo" of a traditional approach to an engineering problem -Will propose and defend the first solution to come to mind

Specific instances of this individual's work activities related to this factor:____

____

__________Numerical Description for this Factor

Scale 4

Problem Recognition and Definition. The ability to understand the cause(s) of a problem.

Numerical Scale		Examples of Performance
9 8 7	more than adequate or acceptable typical performance on this factor	-Able to recognize quickly the existence of a technical problem before all the negative symptoms are apparent -Able to distinguish between symptoms and causes of a problem -Is able to identify a specific problem as being an example of a general class of problems which has certain possible solutions -Goes to the location of a problem to get direct information about it
6 5 4	adequate or acceptable typical performance on this factor	-Usually determines the cause of a problem as the project progresses -Considers other people's opinions about the cause of a problem -Often unwilling to offer a tentative diagnosis of a problem based on observable symptoms
3 2 1	less than adequate or acceptable typical performance on this factor	-Often attacks the first symptom of a problem, rather than looking for its real causes -Often misses one or two important factors in a problem -Usually is not able to see which problem symptoms are related to each other and treats each symptom as if it were a separate problem

Specific instances of this individual's work activities related to this factor:____

____

__________Numerical Description for this Factor

Administrative Skills

Scale 1

Technical Communication. The ability to transmit written and oral information related to technical projects and assignments.

Numerical Scale		Examples of Performance
9 8 7	more than adequate or acceptable typical performance on this factor	-Can sell, orally and in writing, a technical improvement to management which is initially opposed to change -Is able to instruct other engineers in new technology -Tailors written and oral technical presentations to fit the audience -Documents difficult technical material effectively
6 5 4	adequate or acceptable typical performance on this factor	-Reports only the core information pertinent to the problem at hand -Communicates well only with engineers within his or her specific technical discipline
3 2 1	less than adequate or acceptable typical performance on this factor	-Written technical reports which are too wordy -Rarely contributes information to engineering staff discussions of technical problems -Frequently has a proposed project rejected by a manager because of a poor presentation -Has difficulty explaining technical results

Specific instances of this individual's work activities related to this factor:____

____

__________Numerical Description for this Factor

Scale 2

Gathering Technical Information from Others. The effort and act of seeking appropriate others in the business for guidance, advice, and reaction to one's own approach to dealing with technical problems.

Numerical Scale		Examples of Performance
9 8 7	more than adequate or acceptable typical performance on this factor	-Asks questions of technical experts to obtain the appropriate and needed information -Willingly asks others for help, but only on significant or difficult problems -Appropriately expands network of people who can be contacted for advice -Knows the appropriate sources of technical information
6 5 4	adequate or acceptable typical performance on this factor	-Occasionally doesn't know where to go for help or what to request -Occasionally has to be encouraged to seek advice of others -Seeks advice of others but sometimes ignores their good suggestions -Limits efforts for obtaining advice to immediate supervisor and close co-workers
3 2 1	less than adequate or acceptable typical performance on this factor	-Seldom asks others for advice; often has to be told to do so -Often assumes that the help of others cannot be obtained or that they can be of little help even if asked -Almost always asks for help on all technical problems

Specific instances of this individual's work activities related to this factor:____

____

__________Numerical Description for this Factor

Scale 3

Organization and Planning. The ability to manage projects and assignments including establishing priorities, meeting deadlines, and attending to details.

Numerical Scale		Examples of Performance
9 8 7	more than adequate or acceptable typical performance on this factor	-Able to establish or appropriately change project priorities without the specific guidance of the supervisor -Prepares schedules identifying project milestones, as well as contingency plans -Offers ideas developed from current projects as proposals for possible future projects -Can coordinate work activities on several on-going projects without missing deadlines
6 5 4	adequate or acceptable typical performance on this factor	-Usually can reorganize a project due to schedule or technical specification change -Is able to use systematic scheduling procedures such as Gantt and PERT methods -Sometimes spends too much time on details
3 2 1	less than adequate or acceptable typical performance on this factor	-Frequently misses project deadlines -Does not follow up through implementation after the major components of a project are completed -Drags out each assignment to the maximum -Uses excessive manpower and equipment resources due to poor project management

Specific instances of this individual's work activities related to this factor:____

____

__________Numerical Description for this Factor

Scale 4

Implementation of Chosen Alternative. The ability to make an alternative operational by fitting the solution to the particular situation.

Numerical Scale		Examples of Performance
9 8 7	more than adequate or acceptable typical performance on this factor	-Anticipates implementation problems and plans for their solution -Accepts minor changes in a problem solution in order to gain its implementation without compromising the design or business objectives -Usually overcomes small obstacles to the implementation of a solution
6 5 4	adequate or acceptable typical performance on this factor	-Makes an idea operational although it may not function at rated capacity -Forces the chosen alternative solution into operation, compromising some of the desired goals of the project
3 2 1	less than adequate or acceptable typical performance on this factor	-Expects every solution to work as smoothly as possible upon implementation -Tries to implement a new procedure before being sure that operating management fully understands it -Sticks with the original solution longer than its performance justifies -Rigidly adheres to textbook solutions without considering the specific situation

Specific instances of this individual's work activities related to this factor:____

____

__________Numerical Description for this Factor

Scale 5

Responding to Change. The extent to which the engineer accepts and actively participates in changes in the way work is performed.

Numerical Scale		Examples of Amounts of this Factor
9 8 7	more than an adequate or acceptable typical amount of this factor	-Actively seeks available information to understand the change -Anticipates and works to minimize the disruptive aspects of the change -Advocates the benefits of the change to others -One of the first to participate in or use the changed approach/method
6 5 4	An adequate or acceptable typical amount of this factor	-Accepts given explanation of reason for change -Tolerates and occasionally tries to overcome disruptive effects of change -Uninterested in discussing the pro's and con's of the change -Participates in the change as it becomes necessary
3 2 1	less than an adequate or acceptable typical amount of this factor	-Does not accept the given explanation for the change -Disrupts implementation of change by trying to cling to old approach/method -Complains to others about the disadvantages of the change -Participates in the change only if told to do so

Specific instances of this individual's work activities related to this factor:____

____

__________Numerical Description for this Factor

Updating Orientation

Scale 1

Professional Activities. The extent to which the engineer participates in professional activities.

Numerical Scale		Examples of Activites Related to this Factor
9 8 7	more than usual amount of typical activity or effort related to this factor	-Seeks leadership roles in professional societies -Teaches a technical refresher course for the local professional society chapter -Frequently presents a paper at a regional or national technical society meeting
6 5 4	usual amount of typical activity or effort related to this factor	-Attends most chapter meetings of the technical society -Has never submitted a paper for presentation at a technical society meeting
3 2 1	less than usual amount of typical activity or effort related to this factor	-Joins professional societies solely only if encouraged to do so -Does not attend professional society functions

Specific instances of this individual's work activities related to this factor:______________________________________

__________Numerical Description for this Factor

Scale 2

Continuing Education Activities. The type of learning procedure used by the engineer to maintain or obtain up-to-date technical skills.

Numerical Scale		Examples of Activities Related to this Factor
9 8 7	more than usual amount of typical activity or effort related to this factor	-Has made definite plans for self-development in technical areas -Devotes a substantial portion of spare time to reading technical publications and taking technical courses -Completes university courses on advanced technical topics -Completes as many relevant company-sponsored technical seminars and short courses as possible
6 5 4	usual amount of typical activity or effort related to this factor	-Completes most technical courses or seminars held outside the company -Completes relevant technical courses only if encouraged by others to do so
3 2 1	less than usual amount of typical activity or effort related to this factor	-Expects the organization and its management to initiate continuing education efforts -Frequently content to rely upon co-workers for learning about new techniques -Never attends an in-house technical seminar -Reads technical literature only when told to by the supervisor

Specific instances of this individual's work activities related to this factor:______________________________

____

_____Numerical Description for this Factor

Scale 3

Work Assignments Sought. The type of job activities desired and pursued by the engineer.

Numerical Scale		Examples of Activities Related to this Factor
9 8 7	more than usual amount of typical activity or effort related to this factor	-Prefers assignments which involve several technical disciplines -Is willing to accept an assignment which has an uncertain chance of success -Tries to get assignments which focus on different applications of a specific technical interest
6 5 4	usual amount of typical activity or effort related to this factor	-Rarely expresses reluctance to accept an assignment -Tends to remain with assignments in which he feels comfortable
3 2 1	less than usual amount of typical activity or effort related to this factor	-Desires assignments which are more administrative than technical -Is content to perform in current assignment for an indefinite amount of time -Tries to avoid assignments in unfamiliar technical areas -Prefers to work on rather routine and mundane assignments

Specific instances of this individual's work activities related to this factor: ____________________

____

__________ Numerical Description for this Factor

Scale 4

Technical Interest and Curiosity. The interest and curiosity shown by the engineer regarding recent developments in science and technology.

Numerical Scale		Examples of Activities Related to this Factor
9 8 7	more than usual amount of typical activity or effort related to this factor	-Seeks information about all technical areas -Seeks involvement in relevant technical developments -Works extra hours on own initiative to learn about new developments
6 5 4	usual amount of typical activity or effort related to this factor	-Occasionally reads journals in related technical areas -Interest in new technology is usually limited to own area only -Sometimes displays a negative attitude toward new ideas
3 2 1	less than usual amount of typical activity or effort related to this factor	-Is pessimistic and cynical about new technical developments -Has little curiosity about technologies related to own specific area -Adopts an attitude of "if it's important, someone will tell me about it" toward developments

Specific instances of this individual's work activities related to this factor:____

____

__________Numerical Description for this Factor

Appendix D

Participation in CE

List the various courses, seminars, training programs, professional activities, and other activities that you have participated in during the past year or are involved in presently that are related to improving your technical knowledge or skills or your job performance. Be sure to include both in-house as well as external courses, seminars, etc.

Content Area of Course or Activity	Duration or Frequency of Course or Activity (e.g., 3 hours per week for 6 weeks; 1 two-hour session; etc.)	Content More Related to Technical, Administrative or Other Area?	Was Your Participation-Supported by Your Organization? How?
1.			
2.			
3.			
4.			
5.			
6.			

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