

**MAINTAINING TECHNICAL CURRENCY AMONG COMPUTER
PROFESSIONALS: A MULTIPLE-CASE INVESTIGATION
OF THE ROLE OF FORMAL AND INFORMAL LEARNING**

by

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(ABSTRACT)

Virtually all government and industry information and control systems rely upon computer professionals for systems development and maintenance. With the national workforce growing at only one percent annually and enrollments in computer and information sciences college programs declining, the need exists to obtain a continued contribution of good work from our existing workforce.

A multiple-phase, multiple-case study research project was performed to develop an understanding of how technical currency is maintained, not as a discrete phenomenon, but within the setting of the work environment, considering project experiences, organizational relationships, professional preparation and continuing professional education, and individual motivation. Previous research

indicated that project experiences contributed to, or provided a vehicle for, maintaining technical currency.

Maintaining technical currency was found to require a continuous process involving organizational relationships, the individual's perceived value in the organization, constant assessments and evaluations of current and desired project involvement or position attainment, repeated and varied learning episodes, and actual project experiences. Individuals were motivated to take specific actions, such as participating in training courses, when such action was expected to yield a benefit. Project experiences alone were not sufficient to maintain technical currency, although they were an essential element. While formal education in preparation for a career was critical, formal courses did not contribute as significantly as other forms of continuing professional education to maintaining technical currency.

A Technical Currency Model was generated that explains how individuals expend energy in one or more of five focus areas depending on their motivation at the time: (a) technical qualification for a project or position; (b) political qualification for a project or position; (c) performing on a project or in a position; (d) determining that change is appropriate; and (e) seeking the next project or position.

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Special appreciation is given to Dr. Wiswell who served as my committee chairman. He was the representative of Virginia Tech that responded to my initial inquiries about the program overall and whether or not the program was appropriate to support my educational and research interests. More than that, Dr. Wiswell helped me design an effective program plan of study, including suggesting an important field study that got the research going in the right direction.

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Most importantly, I am indebted to the computer professionals that participated in this effort, either in one of the preliminary studies or as respondents in this project. I learned a lot from them. I hope that they feel that the results of this effort made their contributions worthwhile.

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CHAPTER ONE

THE PROBLEM

Technical obsolescence is a serious concern for computer technical professionals, their organizations, and users of their products and services. This research provided a better understanding of the process of maintaining technical currency, with special insight into the contribution of project experiences.

INTRODUCTION

Following are quotes by managers in a large electronics company taken from a previous study investigating technical obsolescence:

"Technology is changing so fast that our older engineers have fallen hopelessly behind."

"Some men can continue to perform at a high level until they are 50 years old, but most go downhill after turning 40."

These statements reflect the concern of technical obsolescence in the engineering field. Of particular interest is that the previous quotes were reported twenty years ago (Dalton and Thompson, 1971, p. 57). These researchers later developed a stage model that identified desired changes in responsibilities, skill sets, and interactions with co-workers throughout a career (Dalton and Thompson, 1986). They recognized that obsolescence was a problem that was not restricted to the engineering field. They found that the solution to the problem was not clear. For example, they found that continuing professional education was not related to long-term performance. They also found that those with high performance ratings also had job assignments that required use of judgement, skill, and knowledge.

THE COMPUTER PROFESSION

This research addressed the same concern of maintaining technical currency over the long-term; however, the people of interest in this case were computer professionals -- computer programmers, analysts, system designers, technology specialists (e.g., data base designers, network engineers), software engineers, and other computer specialists.

The work of the computer professional has changed significantly over the last twenty years. The knowledge needed today for system designers, for example, includes an understanding of design methodologies (e.g., structured versus object-oriented design), relational database technology, fourth generation languages, and database and network interoperability. A specific example relates to the microcomputer, which did not even exist in the 1970's. Today's systems typically involve decisions about the proper mix of microcomputers, minicomputers, and large mainframe computers. The computer professional has to deal with today's technology mix, even though most of these computing alternatives and related issues were not part of formal education programs even ten years ago.

BACKGROUND

Four related activities led to this research. First, the researcher's twenty-two year career in the computer profession increasingly involved working with or directing technical staffs. Second, during coursework at The Johns Hopkins University in their Engineering Technical Management Master's program, several aspects of technical personnel management were considered. In particular, the concept of technical obsolescence among engineering

personnel was introduced. The Dalton and Thompson research raised serious concerns about an organization's ability to understand and support a technical career. This fueled a personal interest in the issue of obsolescence, but focused on the computer professional. Third, the researcher's coursework in the Adult and Continuing Education doctoral program at Virginia Tech focused on adult learning theories and practices, issues, and research, which provided insights into the potential contribution of informal learning in the work-life of professionals. Specifically, learning from project activities was one of the critical issues at hand. Maintaining technical currency must be examined from an adult learning perspective since the subjects of interest are indeed adults in a working and learning environment. Fourth, three preliminary research initiatives were conducted to prepare for this investigation.

The first of these preliminary research efforts was a descriptive study that investigated performance ratings and potentially related factors. That effort involved quantitative research and analysis of a large convenience sample. The second initiative was a follow-up survey which collected additional data about the people and their job and educational experiences. The third effort was a pilot case study to develop preliminary research

propositions and to determine if case study research was a viable approach to investigate this problem.

Convenience Sample and Survey

The performance evaluation and administrative records of 505 computer technical professionals were analyzed in a convenience sample to investigate relationships between performance ratings and personal, job, and educational attributes. Then, a survey of 75 subjects, selected from the larger sample in the descriptive study, was taken to investigate relationships of age, formal education, continuing education, training, and job history with performance rating. Several questions were included on the survey questionnaire to obtain data related to perceptions of work capacity, time span of discretion, and job complexity. Time span of discretion is the amount of time that the person has on the job to exercise independent actions. Jaques (1956) stated that the longer the period an employee has to exercise discretion, the greater degree of responsibility is inherent in the job. Work capacity deals with the capacity of the individual, not the job. Work capacity is the measure of the extent to which the person desires to work without feedback and direction. It should be noted that the supervisor's rating of performance

is not necessarily equivalent to a specific level of technical currency. Level of technical knowledge was one of fifteen criteria used to develop an overall performance rating. For the technical personnel in this sample, degree of technical knowledge was one of the more important considerations when assigning an overall performance rating.

The descriptive research indicated that the most significant relationships with performance rating were the last performance rating (top rated employees were more often top rated the prior year), then years employed with the company (top ranked employees had been with the company longer than others). While a pre-study analysis of 200 technical personnel from one work location reported a relationship (Woodard, 1990), age was not shown to be related to performance at the aggregate level in this larger sample. However, age and performance evaluation did show a relationship when the three most senior skill levels (senior member of the technical staff, computer scientist, and senior computer scientist) were analyzed separately. The 75 person survey also showed a relationship of years with the company with performance rating, as well as the employee's self-rating of work capacity and time span of discretion. The top performers had a significantly different (longer) perception of their work capacity and

time span of discretion. The number of projects worked in the last year and last five years was also positively related to performance rating. College level was also related to performance rating when employees with less than four years employment with the company were excluded from the analysis.

Pilot Case Study

A single-case pilot study was conducted prior to this study to examine possible factors contributing to technical obsolescence among computer professionals. The object of investigation for this case study was an individual, a senior computer scientist with experience in private industry and government service. The inferential process was directed at key events and processes and relationships that occurred throughout his career that affected his ability to maintain a high degree of technical currency. The principal finding from this research was that it was apparent that project experiences were contributors to maintaining technical currency -- either as direct contributors or as vehicles that facilitated continued learning. It was not clear how or to what extent education, on-the-job learning, and continuing professional education contributed to maintaining technical currency.

The role of the project as a path for on-going learning to remain technically current was a focus of this research.

STATEMENT OF THE PROBLEM

Technical obsolescence can take on several meanings, such as worn out, lacking, or discarded. For this discussion, the term technical obsolescence refers to people whose work habits, approaches, and technical knowledge have not kept up with the state-of-practice, which itself is generally a few years behind the state-of-the-art. Technical currency, conversely, refers to people who have been able to keep skills current, are considered by their peers and superiors to be valuable members of the team, are knowledgeable about the state-of-practice, and are generally knowledgeable about the state-of-the-art. The results of this study added a new dimension to the definition of technical currency: technical currency took on different meanings at particular work locations. Respondents equated technical currency with employability; thus, technically current meant that an individual was up-to-date with a specific technology mix.

The "Civil Service 2000" report (Hudson Institute, 1988) prepared for the U.S. Office of Personnel Management acknowledged the need for maintaining a competent technical

workforce. Noting that half of the federal workforce that will be in place in the year 2000 is already employed today, and that it will be difficult to hire professional employees, the government will have to invest heavily in the continuing development of the skills of those it retains. Demographic projections add to the problem; the national workforce will grow at only one percent annually. Thus, the continued contribution of "good work" from current employees is essential. The problem will become even more critical if current trends in education continue. The Department of Education revealed that, for the third year in a row, undergraduate degrees awarded in computer and information sciences dropped. A decrease in enrollments of 27 percent occurred in that period (Richards, 1990). Given that new workers entering the job pool are expected to increase at only one percent annually, coupled with the fewer number of candidates preparing for a career in computer and information sciences, the need for the current workforce to remain technically current throughout their careers is clear.

This study was performed to investigate the process by which computer technical professionals maintain technical currency and prevent technical obsolescence. The contribution of project experiences was a particular area of focus. The overriding question that this research

investigated was "What is the role of project experiences in helping to maintain technical currency among computer professionals?"

RESEARCH QUESTIONS

In order to achieve the purposes of this research the following study questions were developed:

1. What is the process by which some professionals maintain currency from project experiences?
2. How have employees increased the likelihood of learning effectively from project assignments?
3. What organizational practices or other barriers have inhibited an individual's ability to maintain technical currency?
4. How has the individual's formal education contributed to the value of project experiences?

IMPORTANCE OF THE STUDY

Given that research had not been published in this specific area, work that provided insight into the problems and potential solutions of technical obsolescence among computer professionals was useful.

This research shed light on the phenomenon of learning through project experiences. Maintaining technical currency required a continuous process involving organizational relationships, the individual's perceived value in the organization, constant assessments and evaluations of current and desired project involvement or position, repeated and varied learning episodes, and project experiences. The results of the study can be used by Human Resource Development organizations to support career development planning and counseling as well as by those people charged with designing continuing professional education programs for computer technical professionals. Most importantly, computer professionals can be motivated to learn how to assess their level of currency and develop strategies to be prepared for required levels of technical understanding and proficiency in the future.

DEFINITION OF TERMS

Several terms describe important concepts, actions, events, and attributes contained in this study:

1. Computer technical professional: refers to individuals whose job is to apply their knowledge of and skills in computer and information sciences to support a client's or employer's mission. For this study, managers

were not considered. Job specialties include overall design of systems, software design and development, programming, testing and evaluating systems, ongoing maintenance of developed systems, and technology area specialists (e.g., network engineer, database specialist, artificial intelligence specialist).

2. Project: refers to a particular initiative. Projects typically involve a core team of people who are associated with the effort from beginning to end and others who are involved during particular phases of the project. Projects can range in length from a few months to a few years and involve a few colleagues or more than a hundred. Larger projects (e.g., modernizing the nation's tax system) are typically decomposed into a series of smaller projects (e.g., modernize the collection system, then the taxpayer assistance system, then the examination and audit system, and so forth).

3. State-of-the-art: refers to the technology and professional practices that have recently been introduced to the field as a result of successful research and development efforts. An example is digital imaging; there are numerous products available commercially today that allow an organization to record actual images of paper transactions (e.g., insurance claims) instead of just recording the data from a form.

4. State-of-practice: refers to what is done and used in the field, rather than what is available in the laboratory. Many organizations elect not to move to a newer technology or approach to doing the work until others have used it successfully. For example, automatic code generators and non-procedural languages offer productivity levels ten times greater than programming in COBOL or FORTRAN (two of the oldest and still most used programming languages); however, these languages are still in use in 1991 because of the installed base of systems that have to be maintained and a workforce that is skilled in these older technologies.

5. Project assignment: the act of being assigned to a particular project. Roles, responsibilities, and expectations are established within the bounds of the project.

6. Technical obsolescence: results when individual work habits, approaches, and technical knowledge have not kept up with the state-of-practice -- which itself is generally a few years behind the state-of-the-art.

7. Technical currency: Refers to people who have been able to keep skills current, are considered by their peers and superiors to be valuable members of the team, are knowledgeable about the state-of-practice, and are generally knowledgeable about the state-of-the-art.

8. Informal learning: deliberate or incidental learning that occurs outside the traditional, structured setting, either on the job or outside the workplace.

9. Performance rating: the measure of an employee's overall performance, considering technical knowledge and other factors, as determined by the employee's supervisor.

10. Work capacity: a self-assessment by the worker that indicates the length of time he or she desires to work without feedback from a superior.

11. Time span of discretion: a self-assessment by the worker that indicates how much his or her job allows him or her to work without feedback from a superior.

12. Continuing professional education: structured learning activities arranged through the employer or taken from outside organizations, such as evening graduate school or professional society-sponsored programs.

13. Career: continuous, long-term employment, either planned or realized, within a particular field; in this case, the computer profession.

14. Career patterns: refers to the job changes made over time during the career, including promotions, changes in responsibilities, and changes of employer.

15. Motivation: refers to what causes job-related behavior as well as how motivation occurs.

LIMITATIONS OF THE STUDY

This research was focused on long-term technical professionals. It did not investigate factors related to technical currency among managers nor among people that have less than 15 years experience in the computer profession.

The study was not a comparative study that contrasted good versus bad performers; instead, the phenomenon of interest was the process by which technical currency is maintained.

This research was based on a premise that on-the-job learning from project experiences is an essential part of the solution to maintaining a skilled professional work force to meet government and industry requirements. Educational activities will and must occur at many levels, including college, graduate school, the work site, and through continuing professional education. This research specifically concerned itself with the problem of obsolescence of in-place computer professionals to develop a better understanding of how project experiences contribute to the long-term technical currency of the more than one million computer professionals in the workforce (U.S. Bureau of the Census, 1989).

ORGANIZATION OF THE REPORT

Chapter I has presented the purpose of the study. It also provided definitions of technical obsolescence and technical currency. In addition, background information was provided that summarized the findings from the preliminary research activities. Finally, the research questions posed were provided, accompanied by the reasons why this research project is an important one.

Chapter II presents several categories of relevant research. While studies examining technical obsolescence in the engineering field have been conducted, research had not been published that specifically addressed the problem of technical obsolescence among computer professionals or the role of project experiences on the ability of computer professionals to maintain technical currency. Relevant literature presented in this section includes research findings and writings related to the problems of obsolescence from an age versus performance perspective as well as in relation to careers, management practices in place today including theories of motivation, and other relevant literature to demonstrate that sufficient research and exploratory work had been done to provide a knowledge base upon which to frame this research.

Chapter III discusses the research methods that were used to conduct this research. The research employed a multiple-phase, multiple-case research approach. Descriptions of the study design and sample selection are provided. The study questions and data collection and analysis techniques are also presented.

Chapter IV presents the findings of the research project. This chapter includes overall findings including a description of the developed explanation. Because the study was in essence a series of three multiple-case study projects, each building on the results of the preceding phase, separate presentations of the findings and analyses from each of the three study phases are provided.

Chapter V provides key conclusions from the literature review, a description of the research methodology, and a summary of the research findings. It also presents conclusion and recommendations for further research.

A list of studies, essays, and other related literature referenced within this document is provided following Chapter V.

The Appendix contains one case analysis report, including the data, to indicate the format and content of the individual case reports produced during the study.

Not included in this document, but available upon request, the researcher will provide the set of appendices

that contain the case study data base. The reports within the appendices document include:

1. Reports from the preliminary research consisting of: (a) the 505 person descriptive study; (b) the 75 person study; and (c) the pilot case study.

2. Ten individual case reports containing: (a) the purpose, background, overall study design, and rationale for the selection of the subject; (b) the case study research design, including study questions, unit of analysis, and logic linking the data to the propositions; (c) procedures; (d) case study question categories; (e) storing, coding, and analysis approach; (f) pattern matching analysis; and (g) the transcription of the interview, annotated with the analysis codes as assigned by the researcher.

3. Three cross-case analysis reports containing: (a) purpose, background, overall study design, and rationale for the selection of subjects; (b) case study research design, including study questions, unit of analysis, and logic linking the data to the propositions; (c) procedures; (d) case study questions; (e) storing, coding, and analysis approach; (f) cross-case comparisons (pattern matching analysis); (g) rationale for analysis code changes; (h) explanation building (theory development); and (i) rival theory discussion.

The results of the ten case studies and three cross-case analyses, including much of the detailed information, are included in Chapter IV. These appendices, however, tell the story of the research in a step-by-step, evolutionary manner.

CHAPTER TWO

REVIEW OF THE RELEVANT LITERATURE

INTRODUCTION

While studies examining technical obsolescence in the engineering field have been conducted, research results have not been published that address the problem of technical obsolescence among computer professionals, nor of the role of project experiences on the ability of computer professionals to maintain technical currency. However, there has been sufficient research and exploratory work to provide a knowledge base upon which to frame this research.

The variables central to this research, in addition to the project and individual, included technical obsolescence, performance of the individual over time, management practices, career patterns, and motivation. The literature review was keyed to the following questions which are based on the research variables:

1. What do previous studies report concerning the relationship between age and performance?

2. What findings have been found from previous studies of technical obsolescence, even if not set in the computer field?
3. Do career patterns influence the onset or prevention of technical obsolescence?
4. How do management practices and adult learning principles address the issues related to long-term technical currency?
5. What are important factors that motivate computer professionals?

The first two questions were reviewed concurrently, since they are related to a high degree; studies of performance over time are in fact studies of age and performance. "Age versus performance" is an important issue in this research. If performance was shown to decrease substantially over time, it would be appropriate to question whether or not a long-term career is even feasible for most computer professionals.

The second question pertains, primarily, to the engineering field, where some previous research was conducted. While engineering careers and computer careers do have some similarities, the entry requirements, professional preparation, and day-to-day activities are substantially different; thus, findings from the engineering field cannot be generalized to the computer

field. However, since both are highly technical fields it was useful to review the findings to help pose study questions.

The third question views the goal of technical currency from a career perspective. In particular, it was useful to know which types of projects and work practices influence long-term technical currency and what the nature of the influence is.

A study of the computer professional has to take into consideration the work environment. Question four pertains to the practices in place that govern the typical work setting. The degree to which management practices and adult learning principles encourage or discourage individual actions to maintain technical currency is of particular interest.

The fifth question addresses the most complex variable, motivation. If the proposition that projects are key to maintaining technical currency was valid, it was useful to investigate the factors that motivated individuals to participate on particular projects.

TECHNICAL OBSOLESCENCE AND AGE VERSUS PERFORMANCE

While studies about the degree of technical obsolescence among computer professionals have not been

published, related research has been done examining obsolescence in the engineering field, as well as research addressing the effects of aging with job performance. While psychological studies have concluded that adults become less efficient at general problem solving skills and process information less efficiently as they age, these studies have focused on the processing dimension primarily, not other aspects of intelligence, such as knowing and thinking (Rybash, Hoyer, and Roodin, 1986). Rybash et al. summarized research by Horn and Catell (1966) and Catell and Horn (1978) that produced the crystallized-fluid model. Crystallized abilities reflect the extent that individuals have incorporated the "valued knowledge of their culture" (Rybash et al., 1986, p. 83). Abilities associated with crystallized intelligence include concept formation, reasoning, and verbal comprehension. Fluid intelligence concerns the abilities associated with processing information, drawing inferences, seeing relationships among patterns, and integration.

The relationship of aging with these intelligence factors differ. Crystallized intelligence improves with age, up to the 60's. Fluid intelligence declines with age. These findings have been supported by other researchers. Brookfield (1988, p.28), citing previous research, reported that "fluid intelligence decreases and crystallized

intelligence increases in adulthood, and adults are able to learn as well in their forties and fifties as in their twenties and thirties, when and if they can control the pace of learning." Brookfield summarized research by Knox (1977) that reported that long-term memory actually improved with age. Indeed, Knox concluded that learning ability was associated more with formal education than with age. Brookfield reported that this finding was supported by earlier research of Knox and Sjorgen (1965) and Knox, Grotelueschen, and Sjorgen (1968). Moreover, this study concerns technical currency, and to a lesser degree, performance as opposed to cognitive capabilities. Thus, other factors are important to consider when investigating the effects of aging (and some decreasing cognitive abilities) on technical currency.

THE DALTON AND THOMPSON REPORT ON OBSOLESCENCE IN THE ENGINEERING FIELD

Dalton and Thompson researched the problems of obsolescence in six technology-based companies (2,500 subjects) in the 1970's (Dalton and Thompson, 1971). Their findings showed that an engineer's performance rating peaked by age 40. For the age group 21-25, an average of 40 percent was reported, meaning that people in that age

group performed better than 40 percent of all people evaluated, regardless of age. For the 26-30 age group, the average performance ranking reported was 46 percent. For both the 31-35 and 36-40 age groups, their evaluated performance was approximately 55 percent. Then, a rapid decline in performance evaluation was reported for each subsequent age group (50 percent for the age group 41-45, 47 percent for 46-50, 40 percent for 51-55 and 32 percent for 55 years old and over). It is important to note that these are average ratings. Dalton and Thompson reported many examples of older engineers receiving top ratings until they retire.

Dalton and Thompson indicated that salary ranking rose with increasing performance evaluations. But after age 40, salary ranking did not fall, even though performance did. The increases in salary fell after age 40, but absolute salaries did not. They noted that the continued high salaries for lower-performing engineers after age 40 was the cause of other concerns as well, such as pay-for-performance and equity.

These researchers continued investigating careers and developed a stage model that identified desired changes in responsibilities, skill sets, and interactions with co-workers throughout a career (Dalton and Thompson, 1986). They recognized that obsolescence was a problem that was

not restricted to the engineering field. They also found that the solution to the problem was not clear. For example, they found that continuing professional education was not related to long-term performance. They also found that those with high performance ratings also had job assignments that required use of judgement, skill, and knowledge.

MCEVOY AND CASCIO'S META-ANALYSIS ON THE RELATIONSHIP BETWEEN AGING AND JOB PERFORMANCE

Glen McEvoy and Wayne Cascio (1989) performed a meta-analysis on 96 independent studies that reported age-performance correlations. Their analysis showed that age and performance are generally unrelated. Interestingly, they found little evidence that the type of job (i.e., professional versus non-professional) altered the relationship between age and job performance.

McEvoy and Cascio were concerned about this possible relationship due to two related trends and new legislation. The first trend addresses an aging work force. They cited the Hudson Institute's (1988) findings that predicted the number of workers between 45 and 65 will grow 41 percent between 1985 and 2000. The second trend is that older workers are increasingly litigious. The legislation that

McEvoy and Cascio believe will increase the number of court cases is the 1986 Age Discrimination in Employment Act amendments that outlaw mandatory retirement. McEvoy and Cascio acknowledged that there is a widespread belief that work performance declines with increasing age -- despite no support in the literature for that belief.

The method used by McEvoy and Cascio to estimate the overall relation between age and performance was meta-analysis. They used a combination of computer-assisted search and non-computer-assisted examinations of reference lists in published studies. They augmented those research strategies with manual searches of articles published between 1968 and 1989 in 46 behavioral science journals. Their selection criteria included the requirement that some precise form of performance measure was included, as well as the specific age of the subjects being included (as opposed to alternative indicators of age, such as tenure). They identified 65 studies with 96 independent samples with a total sample size of 38,983. Of these, 56 studies reported positive correlation (i.e., performance ratings increasing with age), two with a 0 correlation, and 38 studies reporting a negative correlation.

After applying meta-analysis formulas, the overall mean correlation was .06, indicating virtually no relationship between age and job performance. They

also looked for moderating variables (e.g., professional versus non-professional, type of performance measure, and age range of samples) and reported only insignificant changes in the correlation.

McEvoy and Cascio noted that their meta-analysis assumed a linear relationship between variables. If the relationship between age and performance for a particular group is curvilinear (such as the results of the Dalton and Thompson study which reported the performance of engineers peaked around age 40), then the near 0 correlations reported may in fact mask a true relationship between age and performance.

ROSEN AND JERDEE'S REVIEW OF AGE AND PERFORMANCE RELATIONSHIP

Rosen and Jerdee (1988) anticipate that current practices of a continuous career of 40 years, followed by retirement, will be obsolete as "we rapidly approach the 21st Century" (p. 37). While the focus of this work by Rosen and Jerdee is on career management of senior employees (i.e., those over 40), they also addressed attitudes and performance of older workers.

As for attitude, they found that perceptions that the commitment of older workers declines with age are myth not

fact. They relied, primarily, on two studies to make this assertion. Diener (1984) performed a literature review and reported that age was not related to subjective well-being. Rosen and Jerdee also reported on a comprehensive review of over 60 articles done by Rhodes (1983) where age was positively related to most job attitudes. Among key findings, age was positively correlated to internal work motivation. No significant relationship was indicated between age and commitment.

Rosen and Jerdee also addressed the possibility that performance declines with aging, especially as reflected in job performance. They cited Rhodes' finding that age seldom accounted for more than 10 percent of the variance in any particular behavior. Rhodes reviewed 25 empirical studies examining age and performance. Among mixed results, Rhodes also reported that studies that controlled for experience showed no significant age and performance correlation in two-thirds of the studies.

Rosen and Jerdee summarized two other relevant studies that further indicated that job performance does not decline with age, generally, but can in certain situations. First, Waldman and Avolio (1986) reported that a small decline in performance with age was detected when subjective criteria were used. Second, Fossum, Arvy, Paradise, and Robbins (1986) suggested that specific

knowledge, skills, and abilities would be factors in a relationship between age and performance, if a relationship existed. However, the principal finding of Fossum et al. was consistent with Rhodes, that reported variances in ability associated with age were too small to affect performance.

OBSOLESCENCE IN THE CONTEXT OF CAREER DEVELOPMENT

The problem of technical obsolescence, primarily in the engineering profession, has also been discussed in the literature in the area of career development. Although some of these works did not involve actual research, valuable analyses and hypotheses concerning technical obsolescence were formulated that assisted in the framing of this research. A different career concern, career plateauing, has also been studied.

ZUNKER'S VIEW OF OBSOLESCENCE

Zunker (1990) views obsolescence as a career planning error. He posited "when an individual does not stay abreast with changing demands, he or she becomes obsolete" (p. 345). Zunker cited Kaufman's (1974, p. 23) definition as "Obsolescence is the degree to which organizational

professionals lack up-to-date knowledge of skills necessary to maintain effective performance in either their current or future work roles."

Zunker also asserted that age is not necessarily the contributing factor and reported similar findings by Kaufman (1974). Instead, Zunker believed that motivation is the greatest single contributing factor.

CLARK AND CORCORAN

Citing Miller (1979), Clark and Corcoran (1988) explained that obsolescence results from technological change outstripping the education of engineers and scientists. This represents knowledge obsolescence or a failure to acquire new knowledge. Miller introduced the notion of the half-life of engineering education, where the content of undergraduate education changed 50 percent in a seven year period. Thus, the concept of the career was a problem; the belief that career preparation lasted an entire career was demonstrated to be inaccurate.

Citing Lindsay, Morrison, and Kelley (1974), rapid obsolescence is seen as a recent phenomenon where the accelerating pace of information generation, advances in technology, and changes in social institutions make it difficult to keep up with developments.

Four broad factors identified by Kaufman (1979) that contributed to the obsolescence problem are: (a) rapid environmental change, such as the introduction of new technologies; (b) organization climates; (c) the nature of the work assigned; and (d) individual characteristics, including personality, motivation, and cognitive attributes. Kaufman reported no evidence that supports the notion of older engineers being more obsolete than younger ones. Kaufman believed that obsolescence was a consequence of organizational practices, including the nature of the work assigned. Summarizing Rothman and Perrucci (1970), the contention was supported that technical obsolescence and career patterns are interrelated. Positions that weaken expertise involve narrowed technical activities, such as extensive administrative responsibilities, application over research activities, and situations involving stable technologies. Clark and Corcoran offered continuing education and re-education to address the "half-life" problem, but noted that such efforts' success in preventing obsolescence has not been demonstrated empirically. They also proposed traditional approaches to prevent obsolescence, such as seminars, workshops, courses, and self-study.

KIDDER'S INVESTIGATION OF AN ENGINEERING GROUP

In The Soul of a New Machine, John Tracy Kidder (1981) chronicled the activities of a small group of computer engineers who designed and built a new minicomputer in only eighteen months. The work setting was a major computer manufacturer in New England. This book, partly ethnographic, partly journalistic, and partly historical, focused on a particular group of engineers who participated in a product development project of significance to the firm. The project involved new computer architectures and faced an accelerated development schedule. The product was produced in time, but required excessive hours for the entire period. The project team had to face and resolve one crisis after another that tested the skill and perseverance of the team. At the end of the project many of the team members were dissatisfied and left the company.

Some of the benefits from the project experience that were noted by the team members while involved in the effort included: (a) the experience would look good on a resume; and (b) visibility, opportunity, and responsibility within the organization. Maintaining or enhancing technical skills or proficiency was not mentioned as a goal or by-product of the experience. The term "pin-balling" was used to describe the principal benefit derived from the project

experience; a success on this effort would, presumably, lead to the chance to work on the next important product in the future.

Kidder reported that a large number of engineers were dissatisfied with their jobs. Among the reasons he cited were the nature of the jobs and restrictive management practices. He also noted the desire among engineers to become managers in order to be acceptable to their peers. In the eyes of peers, the attitude that Kidder reported was that a person was a failure if he or she did not become a manager. He noted that it was a struggle for older engineers to keep up with younger engineers as well as to keep up with the constantly changing technology of computers. Kidder also noted that the short product cycles led to repeated crisis atmospheres, which led to a constant feeling of being tired that affected computer engineers as early as in their thirties.

CAREER PLATEAUIING

Plateauing is a point in a career where advancement is stopped, not because of the capability of the individual, but because the opportunity to progress does not exist in the organization. Leibowitz, Kaye, and Farren (1990) explained four causes of plateauing. The first cause is

demographics. As "baby boomers" have reached their forties, there simply are not sufficient management jobs available to them (and many people still view promotions as the measure of success). The second cause of career plateauing is the changing nature of organizations. The trend is for fewer management layers, as organizations flatten for cost efficiency. The third explanation offered relates to organizational life cycles. As large organizations slow down, they offer fewer opportunities for movement within the organization. The fourth cause stems from new values being adopted by the workers themselves. Some people consider meaningful work that enhances their personal growth important to job satisfaction. Positions that do not offer personal growth and enhancement lead to employee dissatisfaction.

Technical obsolescence, conversely, relates to skill and knowledge deficiency of the individual, as opposed to career grid-lock that stems from lack of opportunity. However, it is possible that plateauing affects technical currency if an individual is not challenged in his or her current position, and stops personal efforts to keep up to date.

MANAGEMENT PRINCIPLES

Thompson and Dalton (1976) pointed out that the career paths and rewards within an organization do not address the real concerns of engineers. For example, the reward system in many organizations is designed to provide incentives to move into management, away from technical work. If status is defined as achieving a management position, then it is difficult to take pride in being a technician.

Management principles are abstract expressions of values and theories that the organization holds and wants applied in day-to-day practice. It is the line supervisor's job to put in use, via practices, the theories espoused by the organization. There is not a definitive management model that fully describes today's advanced technology-based organization; indeed, there can be great differences between organizations based on the leadership of its founders and directors, business objectives, public or private ownership, years in existence, and many other factors. There are two sources, however, that typify the underlying principles or espoused philosophy of many of today's organizations: the works of Peter Drucker and Peters and Waterman.

PETER DRUCKER

Peter Drucker is one of the most prolific writers on management; he has covered nearly every conceivable aspect of an organization, from values and goals to performance. It does not do justice to Drucker's work to try to summarize it. Instead, this review will only consider Drucker's framework for management and organizational theory. Drucker bases much of his analyses and recommendations around five dimensions and dynamics of working (Drucker, 1976):

1. Physiological: people need a safe environment, fitting for their work.
2. Psychological: people need a modicum of control, positive reinforcement, and recognition.
3. Social: people need other people, such as community and other social bonds.
4. Economic: people have concerns over buying power.
5. Power: people require responsibility and authority.

On the surface, these seem to correspond to Maslow's (1943) "Hierarchy of Needs" human motivation model (from physiological, to safety/security, to social, to esteem, and finally, to self-actualization; these are briefly described later in this chapter). According to Drucker,

the dimensions of working are not a hierarchy. All five are always there; but, immediate needs can shift from one dimension to another.

Drucker's principles have implications for personnel management and development practices. Drucker places a lot of responsibility on the organization, to make common men do uncommon things. Drucker's principles imply that the organization must make every job rewarding and satisfying, with an uncompromising emphasis on integrity of management. That is a difficult challenge for any organization.

PETERS AND WATERMAN

The intent of Peters and Waterman's landmark report on the management practices of the high-tech industry, In Search of Excellence (1982), was to address those qualities of good management that many managers had ignored. Their book received a lot of attention throughout the high-tech industry. When the book was published, American companies were too involved in the "analysis-paralysis" syndrome, where too much was studied and not enough done. When many eyes, especially those in academics, looked to Japan for the answer, this work showed that there were worthy models of management in the United States.

The authors' major message is that U.S. companies can regain their competitive edge by paying more attention to people, both customers and employees, and by sticking to the skills and values they know best. The eight characteristics of the best-run American companies presented by Peters and Waterman were: (a) a bias for action, (b) close to the customer, (c) autonomy and entrepreneurship, (d) productivity through people, (e) hands-on and value-driven, (f) stick to the knitting, (g) lean staff, and (h) simultaneous loose-tight properties.

These characteristics also imply that the organization is primarily responsible for the well-being of its employees. The organization must inspire people at the bottom of the organization to focus on quality and service. Peters and Waterman see the senior management of high-tech organizations as being cheerleaders, promoting values such as "being best."

ADULT LEARNING PRINCIPLES

Adult learning principles can be thought of as prescribed relationships between adult learning theory and practices that are generally accepted by the adult education community. Each principle has implications for practice (i.e., the teacher/facilitator uses different

methods and techniques depending upon the adult learning principles that he or she supports).

There is not a definitive, universally accepted model that fully explains how adults learn. Two perspectives of adult learning are addressed in this review: (a) Malcolm Knowles, and (b) Darkenwald and Merriam. Knowles, instead of other practitioner-oriented adult educators (e.g., Knox, Nadler, and others), was selected because his approach, called Andragogy, has been adopted by many trainers. Andragogy is a widely accepted term that describes the unique aspects of adult education in practice today. The work of Darkenwald and Merriam was selected because they have developed a comprehensive synthesis of modern adult learning theories.

MALCOLM KNOWLES

Malcolm Knowles is one of the leading proponents of Andragogy, the art and science of adult learning. Although he did not invent the term, and many of the assumptions he presents are based on previous works, Knowles is given much credit for popularizing Andragogy in practice. Knowles' assumptions of Andragogy (1984) are:

1. The concept of the learner is increasingly self-directed.

2. The role of the learner's experience is a rich resource for learning by self and others.

3. The learner's readiness to learn develops from life tasks and problems.

4. The learner's orientation to learning is task centered.

5. The learner is motivated by internal incentives.

DARKENWALD AND MERRIAM

Darkenwald and Merriam (1982) summarized eight principles of learning relevant to adult learning based on the theories of cognitive theorists, behaviorists, and Gestaltists. These principles can serve as guidelines for practice:

1. An adult's readiness to learn depends upon the amount of previous learning. The more knowledge accumulated previously, the better the learner is able to learn new information.

2. Intrinsic motivation produces more pervasive and permanent learning.

3. Positive reinforcement of learning is more effective than negative.

4. Information should be presented in some organized fashion, e.g., around concepts, or from simple to complex.

5. Learning is enhanced by repetition, preferably spaced over a period of time.

6. Meaningful material and tasks are more easily learned and longer remembered than non-meaningful material.

7. Active rather than passive participation in the learning activity enhances learning.

8. Environmental factors affect learning. Noise, crowded seating, temperature, and other factors can interfere with the learning process.

ADULT LEARNING PRINCIPLES COMPARED WITH MANAGEMENT PRINCIPLES

The management principles presented earlier place the responsibility for productivity on the organization. The organization must create a good environment, operate in an open and honest manner, and reward individual excellence. Rather than having a focus on "how does an employee become excellent," these popular principles of management concentrate on how an organization can set the stage for productivity.

The adult learning principles cited previously, conversely, do a better job at involving the individual; indeed, they focus on the individual. These principles, too, place a large burden on the organization to properly

identify requirements, to plan, design, conduct, and evaluate effective development programs, and to appropriately consider the individual learner. These adult learning principles consider individuals as independent actors that organizations should support.

These management and adult learning principles reflect a subset of the principles in place overall. Moreover, there are work practices and other efforts that can serve to bridge the gap, such as the management and group learning principles involved in total quality management initiatives. It is important, however, to recognize this apparent conflict between these leading management and adult learning principles.

MOTIVATION

Motivation is a complex concept that attempts to explain why some people initiate work-related behavior and others do not. The major theories can be classified into two categories: (a) content theories that address what motivates people; and (b) process theories that are concerned with how motivation occurs (Hampton, Summer, Weber, 1987).

CONTENT THEORIES

Content theories explain motivation in terms of needs. Peter Drucker's management principles, summarized earlier, were said to be based on five dimensions and dynamics of working (physiological, psychological, social, economic, power) that corresponded to the hierarchy of needs concept developed by Abraham Maslow (1943) and popularized by Douglas McGregor (1966).

Abraham Maslow: Hierarchy of Needs

Maslow depicted human needs in the form of a hierarchy, where the lowest level of unsatisfied needs have the most influence on a person's behavior. Once that need is satisfied, it ceases to be a motivator (unless it becomes unsatisfied again later). The next level of need on the hierarchy then becomes the principal influence until that need is satisfied. Maslow identified five categories:

1. Physiological: the most basic survival needs, including food, water, and shelter.
2. Safety (or security): the need for protection from the natural elements and man-made dangers and disruptions, such as crime, unsafe working conditions, and unwanted changes.

3. Love (or social needs): the need to belong and associate with other people, groups, and the community.

4. Esteem: the need to have self-esteem.

5. Self-Actualization: the needs to have dignity, self-esteem, the esteem of others, and opportunities to further develop and express abilities.

A sixth level was later posited by Maslow (Boucouvalas, 1983). Self-Transcendence is the term used to indicate this higher level of Self-Actualization, where the need to serve humanity is the focus and need, rather than the need for personal self-gratification. Maslow reported that less than one percent of the population has attained this level.

Several variations of Maslow's model have appeared in the literature over time; however, the fundamental notion of a hierarchy of needs, each most influential when not being met, is consistent. However, it is not clear that this model can explain most motivations in the workplace, where, presumably, the lower tier of needs have been met.

Frederick Herzberg: Hygiene Theory

Herzberg's study of engineers and accountants (1976) introduced the concepts of satisfiers and dissatisfiers. The factors associated with the desire in individuals to

improve job performance were categorized as satisfiers-motivators, while the factors associated with a loss of work effort were termed dissatisfiers-hygiene. The term "hygiene" was used because the factors related to dissatisfiers were often environmental, related to policies and procedures, salary, and supervision.

The fundamental notion of the Herzberg model is that dissatisfiers-hygiene factors cause negative performance when these factors exist, but once satisfied, do not impact performance. Only the motivator-satisfier factors can lead to increased productivity. The satisfiers are (a) achievement, (b) recognition, (c) the work itself, (d) responsibility, and (e) advancement. The dissatisfiers are (a) company policy, (b) supervision, (c) salary, (d) interpersonal relations, and (e) working conditions.

Other Content Theories

Hampton et al. (1987) summarized several other content motivation theories as either achievement, affiliation, or power. The achievement motive, described by David McClelland (1962), proposes that people with a strong need for achievement will be demotivated when the job lacks challenge, feedback, and recognition, and, conversely, motivated to higher performance levels when these

attributes are present and fulfilled. The affiliation motive, also reported by McClelland, reports that people with a high need for affiliation with others will seek the company of others and take actions to be liked by the others. Clearly, this characteristic could enhance or cause performance problems depending on the nature of the job. For example, a technical leader may appear indecisive if he or she has trouble making decisions that may affect his or her popularity with the group. Another source of motivation reported by McClelland is the power motive, where people with a high need for power spend more time thinking about how to achieve power and to exert influence.

PROCESS THEORIES

Process theories attempt to explain how motivation occurs in individuals. Hampton et al. (1987) described two types of process theories of motivation: expectancy theory and equity theory.

Expectancy Theory

Hampton (1978) defined the four key elements of expectancy theory: (a) expectancy is a belief about the

result that will occur from particular action; (b) valence is the strength of the desire for a result; (c) instrumentality is the degree to which one outcome leads to another outcome; and (d) subjective probability is the individual's estimate of the likelihood of a particular expectancy or instrumentality. Expectancy theory, generally attributed to Vroom (Hoy and Miskel, 1978), links performance to expected results. For example, a person will engage in an activity if performance is expected to derive from effort and that performance was viewed as instrumental to getting something that the person wanted. If the end result has high valence (wanted very much) and the individual's subjective probability was high (the personal estimate of the likelihood of the relationship of effort and performance, and performance to reward), then the effort is likely to be quite good. If one or more of these elements is negative (such as the subjective probability being low because raises are not viewed as being based on performance) then the individual's effort will be diminished.

Equity Theory

Adams and Freedman (1978) described a second process theory of motivation termed equity theory. Its primary

premise is one of fairness; treatment of people is right. The theory explores how people resolve or react to perceived inequities. Perceived inequities is an important distinction, because people experience cognitive dissonance when they see a difference between what they perceive and what they think is right. Studies that backup this theory report that underpaid workers reduce their productivity to make-up for perceived inequities (Goodman and Friedman, 1971; Pritchard, 1969).

SUMMARY OF LITERATURE REVIEW

This chapter presented related literature from several perspectives: (a) technical obsolescence addressing the effects of age on performance; (b) obsolescence in the context of career development; (c) management and adult learning principles; and (d) personal motivation.

Key findings were: (a) the project experience is an important factor; (b) organizations do not, generally, address key concerns of technical workers; (c) many management principles place an emphasis on the organization rather than on the individual; while (d) popular adult learning principles focus on the individual, more so than on the organization, and recognize the individual as an independent actor; and (e) performance does not generally

decline with age, but can in certain situations; and (e) motivation is a critical factor in maintaining technical currency. These findings, along with the findings from the preliminary research activities, led to the development of study propositions that were tested in this research project.

These findings, though, did not result from studies investigating technical obsolescence among computer professionals, as none existed. As reflected in this chapter, however, there has been notable research and exploratory work in related fields and important research addressing the key variables of this problem. This provides a knowledge base upon which to frame this research project involving computer technical professionals.

The next chapter discusses the research method used to conduct the study.

CHAPTER THREE

METHOD

PURPOSE

The purpose of the study was to gain an understanding of how computer technical professionals maintain technical currency over a career, with particular interest on the role of project experiences. Preliminary research indicated that project experiences contribute to, or provide a vehicle for, long-term technical currency.

OVERVIEW OF THE RESEARCH APPROACH

The basic research method employed was qualitative research. A multiple-phase, multiple-case study approach was used to describe the role of project experiences in maintaining technical currency, not as a discrete phenomenon, but within the setting of the work environment, considering organizational relationships, professional preparation, continuing professional education, and motivation. Preliminary study propositions were established based on preliminary research and literature

reviews. In the first phase, three case studies were conducted with the data incrementally analyzed and tested against the propositions in individual case reports. A preliminary theory was generated in a cross-case analysis report. In the second phase three additional case studies were conducted, each analyzed separately. The theory was refined in a second cross-case analysis, resulting in the formation of a general Technical Currency Model. The third and final phase of the research project tested the generalizability of the model. Four additional case studies were conducted involving subjects from different types of organizations. Similarly, data was analyzed and propositions were tested in individual case study analyses. A final cross-case analysis resulted in a determination about the generalizability of the model, the model being refined slightly, and areas for future research identified.

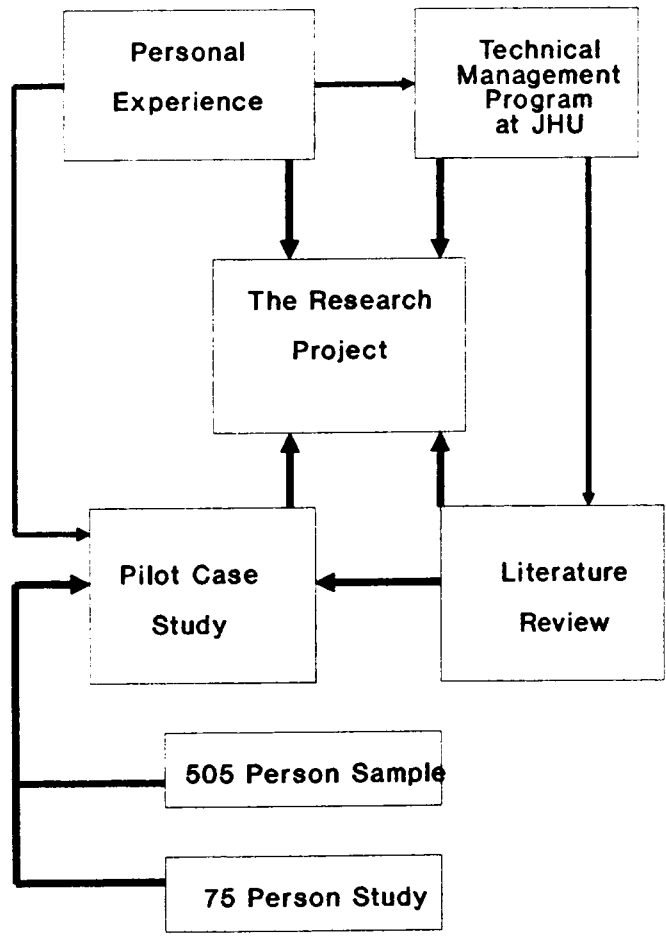
BACKGROUND

Three preliminary studies were conducted prior to this research. The first research activity involved descriptive research. The performance evaluation and administrative records of 505 computer professionals were reviewed to investigate relationships between performance ratings and personal, job, and educational attributes. Second, a

survey of 75 subjects was conducted to investigate possible relationships of age, formal education, continuing education, training, and job history with performance rating. Third, a pilot case study was conducted to test the preliminary propositions developed as a result of the two previous studies and to test the viability of the case study research method for investigating this problem. Figure 1 depicts the relationship of the research activities.

Descriptive Research

A field study was performed in the summer of 1990 to investigate relationships between performance ratings and personal, job, and educational attributes. The performance evaluation and administrative records of 505 computer professionals were reviewed in a convenience sample. This 505 person sample indicated that the most significant relationships with performance rating were the last performance rating (top rated employees were more often top rated the prior year), then years employed with the company (top ranked employees had been with the company longer than others). While a pre-study analysis of 200 technical personnel from one location did report a relationship (Woodard, 1990), age was not shown to be related to



RELATIONSHIP OF RESEARCH ACTIVITIES

FIGURE 1

performance rating at the aggregate level in this larger sample. However, age and performance evaluation did show a correlation with certain skill levels when analyzed separately. One lower-level skill level showed a positive relationship, indicating that performance level decreased (i.e., had a greater value) as age increased. This could suggest that performance rating declines when the individual plateaus within a skill level rather than transitioning through it.

Survey Research

A survey of 75 subjects, selected from the previous 505 person sample, was then taken to investigate relationships of age, formal education, continuing education, training, and job history with performance rating. Several questions were included on the survey questionnaire to obtain data related to perceptions of work capacity, time span of discretion, and job complexity. The 75 person survey also showed a relationship of years with the company with performance rating, as well as the employee's self-rating of work capacity and time span of discretion (the top performers had a significantly higher perception of their work capacity and time span of discretion). The number of projects worked in the last

year and last five years was also related to performance. College level was also related to performance when employees with less than four years employment with the company were excluded from the analyses.

Pilot Case Study

A pilot case study was then conducted to examine factors contributing to technical obsolescence (and concurrently, the prevention of technical obsolescence). The object of investigation for this case study was an individual, a senior computer scientist with experience in private industry and Government service. The inferential process was directed at key events and processes and relationships that occurred throughout his career that affected his ability to avoid technical obsolescence.

Questions were grouped into the following categories: those related to (a) education in preparation for a technical career in the computer field; (b) continuing professional education; (c) the value of job assignments in providing opportunities for learning; and (d) the organization.

To help guide the development of codes after the data had been collected, a high-level accounting scheme was used as a guideline (these were not study-specific codes that

reflected preconceived notions; instead, they established general domains). The six domains were: (a) acts, (b) activities, (c) meanings, (d) participation, (e) relationships, and (f) settings (Lofland, 1974). Analysis of the dialogue showed that distinct categories emerged that were more precise. The refined set of categories were: (a) learning, (b) management, (c) relationships, (d) education, (e) career, (f) environment, (g) problem solving, (h) individual characteristics, and (i) projects. Sub-categories (e.g., work and home environment) were found to be appropriate for most of the categories. These categories were used during the analysis of cases during this research project. The principal finding from the pilot case study was that it was not clear how or to what extent education, on-the-job learning, and continuing professional education contributed to maintaining technical currency. It was apparent that project experiences were contributors to maintaining technical currency, either as direct contributors or as vehicles that facilitated continued learning.

STUDY DESIGN

Because the literature review suggested that theories regarding the role of project experiences in maintaining

long-term technical currency for computer professionals did not exist, developing theory was a goal of this study. To develop theory based on the collected and analyzed data, procedures prescribed by Glaser and Strauss (1967) were utilized, within an overall study design suggested by Yin (1989) for case study research. Grounded theory is particularly appropriate when little theory has been developed related to the research problem (Merriam and Simpson, 1989). Qualitative research is appropriate for trying to answer the "why" and "how" questions that are of most interest in this study. "To explain a phenomenon is to stipulate a set of causal links about it" (Yin, 1989, p. 113). The purpose of theory development in this case was to explain the process by which technical currency is maintained.

This research project followed a carefully planned iterative process based on Yin's approach to case study research to accomplish explanation building:

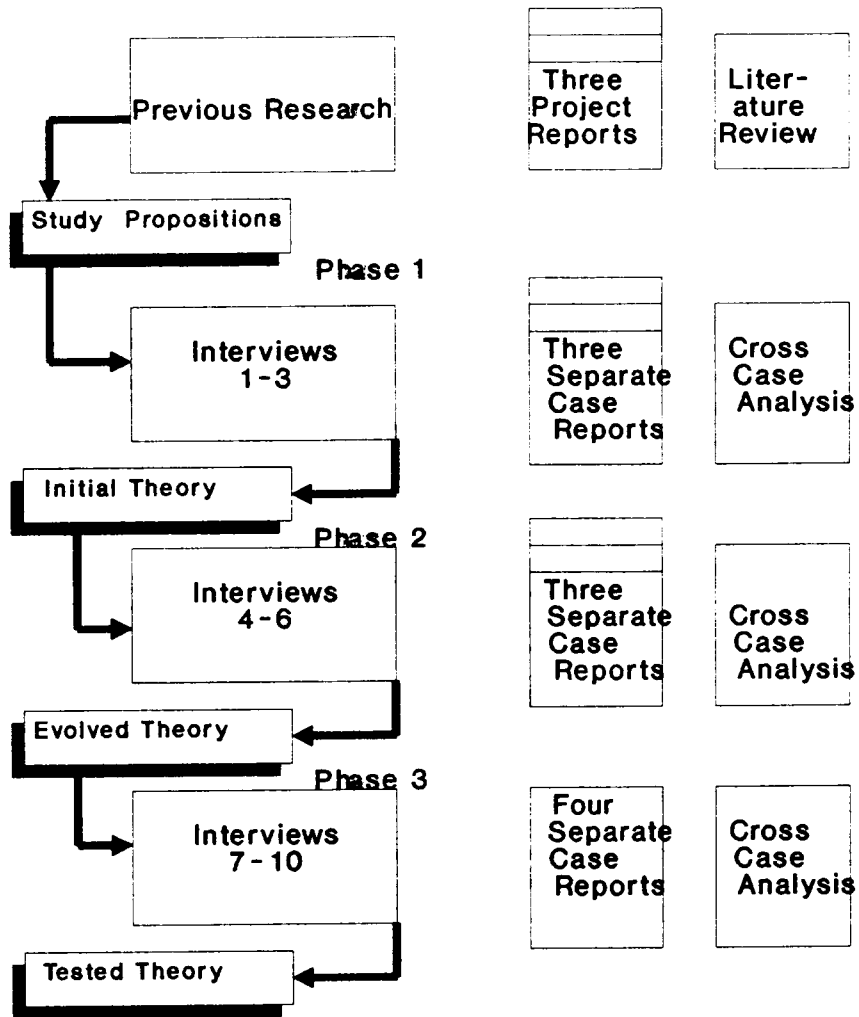
1. An initial theoretical statement or initial propositions were made.
2. The findings of an initial case were compared against the propositions.
3. The propositions were revised.
4. The other details of the pilot case were compared against the revisions.

5. The facts of a second, third, and fourth case (and more) were compared to the revised propositions.

6. The process was repeated as necessary.

The multiple-phase, multiple-case research project is displayed graphically on Figure 2. The first phase consisted of three individual case studies and a cross-case analysis. This phase of the research resulted in revised analysis categories, slightly modified propositions (including two new propositions), and an initial theory generated from the analysis. The second phase repeated the process; it resulted in a refined theory. The analysis of the second set of cases, reported individually and collectively in a cross-case analysis, indicated that: (a) the propositions were supported; (b) the theory developed after the first cross-case analysis did not change significantly; (c) the coding and analysis process after the second set of case studies did not reveal new concepts or dynamics; and (d) rival theories were not supported.

Because of these results, the project could have been considered completed, in terms of developing theory to explain how technical currency is maintained. This theory could then be put to different tests using different research designs and subjects. However, a third phase was conducted to determine the degree of generalizability that could be attached to the Technical Currency Model. To



CASE STUDY RESEARCH DESIGN

FIGURE 2

determine a degree of generalizability of the findings, and to assess the confidence in the theory, a third set of case studies was conducted involving people from different types of organizations. This final set of cases was not based on sampling design (i.e., to build up a larger sample size); it was to establish replications of the theory and, indeed, establish the degree of confidence in the results.

DESIGN QUALITY

The study design featured approaches and mechanisms to achieve proper design quality. The design quality concerns were reliability, internal validity, construct validity, and external validity.

Reliability was addressed by strict adherence to the case study design; pre-designed questions were used in all cases. When a new class of question was introduced (to collect data related to people, events, or situations that had lasting influences on the respondents), it was asked of all respondents. A case study data base was also maintained. An individual case report was prepared for each case; this report contained a transcription of the respondent's responses with the researcher's analysis codes noted. The individual case reports also documented the selection approach used to select the respondent for the

study and an assessment of how the particular case supported or did not support each of the study propositions.

Internal validity was addressed by using two techniques of analysis, pattern matching and explanation building. Pattern matching involved matching the results of each case to the previously developed propositions. If the patterns coincided, there was good reason to believe that the research design had internal validity (where certain conditions were shown to lead to other conditions). Explanation building, where the goal was to analyze the case study data by building an explanation about the case, followed an iterative path. As case study evidence was examined the theoretical propositions were revised. The iterative path that this process followed was documented in cross-case analysis reports at the completion of each of the three phases of the research project.

Construct validity was addressed by using multiple sources of evidence; ten subjects from four different organizations were involved in the study. The results of each individual case study, including an assessment of how the particular respondent supported or did not support each study proposition, as well as a summary of the developed theory, were provided to the respondents for their review.

External validity was addressed in two principal ways. First, replication logic was used in multiple case studies. This process was based on analytic generalization, where the previously developed theory was used as a template to compare results of the case study. Replication occurred when more than one case supported the theory, and importantly, did not support rival theories, which were also explored in this study. Second, the third phase of the study used respondents from different types of organizations than those involved in the first two phases of the study where the theory was initially developed and refined.

SAMPLE SELECTION

Ten subjects were selected from 3 classes of organizations.

Selection of Organizations

Three classes of organizations were included in the study: (a) computer systems and services firms, (b) computer product firms, and (c) government agencies.

Computer systems and services firms are those whose primary mission and source of revenue is providing

computer-related services to its clients. The services are provided in the form of consulting, software development, operations and maintenance, and other actions that are based on the technical expertise of the firm's employees. The largest American firms as of 1991 in this category are Electronic Data Systems, Anderson Consulting, Computer Sciences Corporation, and the systems integration business unit of IBM. Several aerospace firms have operating units that are dedicated to systems and services as well. Aerospace firms in this business area in 1991 include TRW, Boeing, GTE, and Martin Marrietta.

Computer product firms are those whose primary business objective is to sell products as opposed to technical services. Representative companies of this type operating in 1991 include IBM (computer hardware), Computer Associates (systems software, such as database management systems), and Microsoft, a major provider of client-server tools and computing products (such as PC operating systems).

The third class of organization, government, includes federal and state government agencies.

The first phase of the research involved subjects from one of the computer systems and services organizations. This type of organization was selected because they employ the greatest number of computer professionals. The

four referenced firms in this class alone employed over one hundred thousand people in 1990.

The second phase of the research again involved subjects from the same organization. Because the theory that was produced in the first phase of the research went beyond a straight-forward conclusion that project experiences led to long-term technical currency, and because the coding and analysis scheme changed significantly, it was prudent to repeat the analysis without introducing different settings.

The third phase of the research involved subjects from computer product firms and government agencies. The cross-case analysis after phase two of the research concluded that: (a) the propositions were supported; (b) the theory developed after the first cross-case analysis held with only slight refinement; (c) the coding and analysis process did not reveal new concepts or dynamics; and (d) rival theories were not supported. To determine a degree of generalizability of the findings, a third set of case studies was conducted involving people from different types of organizations. The final phase was not based on sampling design, to build up a larger sample size; instead, it established replications of the theory to determine the degree of confidence in the results.

Selection of Subjects

Three subjects were selected for each of the first two phases; four subjects were selected for the third and final phase of the research project. The selection criteria for the subjects were: (a) a minimum of fifteen years of experience in the computer field; (b) classified in a position that had, primarily, technical responsibilities; (c) did not work with the researcher; and (d) was considered technically current (as indicated on a performance evaluation or as reported by a superior in the organization).

The number of subjects was not imposed prior to the start of the study; however, it was expected that the number would be at least six, and certainly under twenty. The rationale for that expected range was based on research design and logistics considerations. First, the research design was interested in replication instead of statistical sampling (Yin, 1989). Correspondingly, based on the preliminary research that included a pilot case study, it was thought that saturation would occur fairly early in the research. Saturation (Glaser and Strauss, 1967) is the point where nothing new is derived from the data. Second, attempting to collect and analyze data from a large number of subjects would have required excessive

time and would have provided very little added value, given that this was a theory generating effort as opposed to an experimental design that could have required many subjects representing different characteristics for each setting of interest.

STUDY QUESTIONS AND RESEARCH PROPOSITIONS

In order to achieve the purposes of this research the subjects were asked questions related to the following study questions:

1. What is the process by which some professionals maintain currency from project experiences?
2. How have employees increased the likelihood of learning effectively from project assignments?
3. What organizational practices or other barriers have inhibited an individual's ability to maintain technical currency?
4. How has the individual's formal education contributed to the value of project experiences?

Because of the preliminary research that preceded this study, including the literature review, a conceptual framework existed. This framework identified the main dimensions and factors involved, as well as presumed relationships. This is consistent with Miles and Huberman

(1984, p. 29): "Bins come from theory and experience, and (often) from the general objectives of the study envisioned. Laying out those bins, giving each a descriptive or inferential name, and getting some clarity about their interrelationships is what a conceptual framework is all about."

The conceptual framework was conveyed in the overall research questions listed previously and in the study propositions that follow:

1. Project experiences contribute to technical currency.
2. Some project experiences are more beneficial in terms of contributing to technical currency.
3. Adequate education in preparation for a career gives some but not all workers the ability to perform initially and adapt (and remain technically current) over time as technology changes.
4. Some people gain more from similar project experiences than others.
5. Assignment to projects involves personal and organizational issues.
6. Characteristics that make a project attractive differ among individuals.
7. Projects that require doing something new are better for maintaining technical currency.

8. Individuals can assess their own degree of technical currency compared to their peers.

Study propositions are used to move the study in the right direction (Yin, 1989). Even with pre-established propositions, this research was not narrowly focused on any particular proposition because the research goal was to discover factors related to the role of project experiences in maintaining technical currency, not to test a hypothesis. Thus, the conceptual framework and related study propositions, while not being a pure grounded theory approach, were not intended to, and did not, prevent the discovery of data. The preliminary propositions were established to guide the study, not to limit it.

The analysis after first phase of the research project led to the development of two additional study propositions that were tested in the subsequent phases: (a) Projects are desirable for reasons that go beyond technical excitement and perceived learning potential, such as the chance to enhance standing within the organization, and (b) individuals engage in multiple types of learning activities, motivated by their view of what is important and the expected benefit.

The analysis after first phase of the research project further led to the slight refinement of the fifth of the original eight propositions to indicate that although

characteristics that make a project attractive differ among individuals (the original statement of the proposition), there are several characteristics that are generally accepted as important.

UNIT OF ANALYSIS

The variables of most interest in the study were the individuals and their experiences. The actual unit of investigation for the study was the process by which the person maintained technical currency, with specific interest on the project itself. The inferential process was directed at key events and processes and relationships that occurred throughout a career that affected an individual's ability to maintain technical currency.

DATA COLLECTION

The selection of the subjects was purposive in the sense that the organizations were accessible to the researcher. However, the individual subjects were not hand-picked by the researcher. They were either selected by someone in their organization or they responded to an inquiry that was also available to a larger group of

people. These steps reduced selection bias on the part of the researcher.

Access to Interviewees

The six respondents in the first two phases were selected from a computer systems and services firm. Two of them were selected from the employee pool at large and four were selected from two technical advisory groups that had been established within the organization.

The two respondents from the employee pool volunteered in response to an inquiry to participate in the study. An electronic bulletin board operated by the company was used to seek volunteers. The first two to respond were selected, if they met the years of experience (15 or more years of experience), type of position (primarily technical) and whose performance evaluations indicated that they were technically current (by having favorable overall performance evaluations and having assessments of "technical knowledge" rated in the highest category).

Two of the other respondents from the computer systems and services organization were members of a corporate-sponsored and supported senior technical advisory group at their corporation. This group, called the Leading Edge Forum, was formed by the company to address technology

transfer across all units of the corporation. The group of hand-picked technicians consisted of approximately 15 people out of a corporation of over 25,000 employees. Nomination to serve on this technical committee required approval from two corporate executives; membership was usually restricted to the organization's chief computer scientist. Thus, serving on this panel reflected the person's established technical reputation in the firm, and established the person as an excellent subject for this study. The first two members of this group that volunteered (also via the bulletin board inquiry) were selected for the study, as long as he or she had 15 or more years of experience in the computer field.

The remaining two respondents were similarly selected. The two respondents chaired Special Interest Groups in a technology area within their corporation. These positions had to be approved by the Corporate Vice President for Technology. The criteria for selection included the candidate having an established technical reputation in the field. There were only 15 to 20 such committee chairmen, out of a corporation with over 25,000 employees. Thus, serving in this capacity reflected the person's technical reputation in the firm, and established the person as an excellent subject for this study. The first two Special Interest Group chairmen that volunteered to participate in

the research effort were selected, if they had 15 or more years of experience in the computer field.

For phase three the selection was left up to the respondent's organization. The researcher contacted someone he knew in various organizations of the type selected for the final phase of the research project, and asked them to select two people that met the selection criteria and would be willing to participate in the study. The first two volunteers for each type of organization desired (computer product firm and government agency) were selected.

Resources

The subjects were guaranteed that their names, or their firm's name, would not be disclosed. This was an important consideration for many of the respondents. The interviews were handled by a combination of face-to-face, telephone, and written techniques, depending upon the preferences of the subjects. The interviews were transcribed and loaded into the "Ethnograph" software package, a PC-based text management system used to support the collection and analysis of the data.

Interview Questions

Seven categories of questions were used in the study to achieve the research objectives. Several questions supported more than one of the primary study questions. The seven categories of interview questions were:

1. Questions related to education in preparation for a technical career in the computer field (relates to Research Question 4).

2. Questions related to continuing professional education (relates to Research Question 4).

3. Questions related to the value of job assignments in providing opportunities for learning and how this learning occurs (relates to Research Questions 1 and 2).

4. Questions related to organization make-up and operation (relates to Research Question 3).

5. Questions related to informal learning and interpersonal interaction in the workplace (relates to Research Question 3).

6. Questions related to knowledge of technical trends and keeping up-to-date (relates to Research Questions 2 and 3).

7. Question related to key influences (relates to Research Questions 1, 2, 3 and 4).

The seventh category was added after the first two cases to address key issues, events, and people that had influenced the respondent in a lasting way. The specific interview questions are presented in the following subsections.

Questions Related to Education in Preparation for a Technical Career in the Computer Field

1. When did you start working full-time as a computer professional? Why?

2. Describe your college education (where, major, minor, business courses, computer science courses, information systems/data processing courses)

3. What courses were most valuable in terms of preparing you for work? Why?

4. Did your education focus on specific technologies and techniques? Or, do you think your education gave you a foundation upon which to expand/adapt over time?

Questions Related to Formal Coursework Taken as Continuing Professional Education

1. Have you taken formal coursework from college(s) since starting your career? How many? How often? Have they been part of degree programs? Have degrees been earned? What subjects? Why were they taken?

2. Do you think that these courses made you a better performer and more technically current? How? If so, what could have substituted for the coursework?

3. Is it your responsibility to keep up to date, or should your employer tell you what courses to take and plan for them, etc?

Questions Related to the Value of Job Assignments in Providing Opportunities for Learning and How This Learning Occurs

1. Do you think learning on the job occurs? How?

2. Is learning on the job vital to keeping up to date?

3. What are the best types of job assignments to have?

4. Do you like to work on one project from start-to-finish, or on just parts of it?

5. Do you like to work on one project at a time or several at a time?

6. What makes a project exciting? Size? Client? Schedule? Colleagues? Technology? What else?

7. What types of projects offer the best learning opportunities? Why?

8. What other factors affect learning from actual work?

9. Describe a job during which you learned something new. How did that happen? Describe another similar situation.

Questions Related to Organization Make-up and Operation, Including Job Assignment

1. Who decides the projects that you will work on at any point in time?

2. Does it matter (in terms of learning on the job and remaining technically current) how your organization is structured and what its practices are?

3. Does your immediate supervisor affect your performance or ability and willingness to stay up-to-date?

4. What do you think an organization can do to foster self-improvement and continued good performance?

5. What [else] do you think affects the ability to remain technically competent over an entire career?

Other Questions Related to Informal Learning and Interpersonal Interaction in the Workplace

1. What are the most important skills that you have developed during your career? How did you develop them? How are these skills important in doing your job?

2. Are you able to learn from other people? If so, how does that work? If not, what prevents it?

3. What position title do you have now? What are your responsibilities? How long have you been in this position?

Questions Related to Knowledge of Technical Trends and Keeping Up-to-date

1. What are the critical technologies needed today?
2. What do you think will be the key technologies, in your organization, five years from now?
3. How will you prepare yourself for the work environment five years from now?
4. What technologies (e.g., UNIX, Ada, C, object-oriented design, etc.) are you least familiar with that you feel are important?
5. What role do magazines and other periodicals play in helping you on the job?
6. What other approaches help you prepare for and then perform on project assignments?

Question Related to Key Influences

1. When you think about your career, certain events or episodes probably stand out in your mind -- things that led to a lasting change in you as a technical professional. Please identify any events, situations, or people in your

career -- things that made a difference in how you perform or view your job.

DATA CODING AND ANALYSIS

The "Ethnograph" software package was used to aid in data collection and analysis. "Ethnograph" is a set of interactive computer programs designed to assist qualitative and ethnographic research. It provided automated support to some of the tedious, mechanical parts of the data analysis process. It did not provide any interpretive support. "Ethnograph" is not an expert system. Simply stated, the software replaced the color-coded "3 x 5" index cards that have typically been used in qualitative research. For example, this software allowed instant retrieval of all phrases related to "LEARNING METHOD." Analyzing the transcripts and assigning the appropriate codes was the researcher's responsibility.

Data Coding

The coding process used the codes developed as a result of the pilot case study. The nine codes were: (a) learning, (b) management, (c) relationships, (d) education, (e) career, (f) environment, (g) problem

solving, (h) individual characteristics, and (i) projects. During the pilot case study, sub-categories of these nine principal categories were developed as a result of analyzing the nature of the content. This allowed grouping of related types of information, while still maintaining very specific "bins." Figure 3 shows the categories and sub-categories of codes that were in place at the start of the case studies.

Data Analysis

Data were analyzed by examining the coded categories for trends or similarities. The methods used to analyze the information included clustering techniques, taking advantage of the hierarchical coding structure, and using the constant comparative method to move from the particulars to the general concepts. Intuitive inferences were made and then self-examined to prevent bias on the part of the researcher.

During the analysis of the first phase's collected information, the coding structure required changing, as some of the information, and the analysis of that information, did not fit well into the initial analysis codes. Several codes were added and several eliminated or combined.

LRN	Learning
LRN-LJ	From Job
LRN-LC	From Coursework
LRN-LM	Method
MGMT	Management
MGMT-E	Environment
MGMT-S	Support
MGMT-B	Behavior
RELAT	Relationships
RELAT-F	Family
RELAT-P	Peers
RELAT-M	Manager
EDUC	Education
EDUC-U	Undergraduate
EDUC-G	Graduate
EDUC-CPE	Continuing Professional Education
EDUC-RU	Recommended Undergraduate
EDUC-RG	Recommended Graduate
EDUC-CPE	Recommended Continuing Professional Education
CAREER	Career
CAREER-J	Job Decision
CAREER-JS	Job Change or Start
CAREER-JE	Job Experience
ENVIR	Environment
ENVIR-H	Home
ENVIR-C	College Full-time
ENVIR-P	College Part-time
ENVIR-M	Management
PROB	Problem Solving
PROB-M	Method
INDIV	Individual Characteristics
INDIV-M	Motivation
INDIV-B	Beliefs
INDIV-A	Attitudes
PROJ	Projects
PROJ-PC	Characteristics
PROJ-PE	Experience

INITIAL ANALYSIS CODES

FIGURE 3

The codes required only slight modification during analysis of the second phase's information. No changes were required during the third phase. The final analysis codes are provided in Figure 4.

Two techniques of analysis were attempted. The first was pattern matching, where the results were compared to the previously developed propositions. If the patterns coincided, there was good reason to believe that the research design had internal validity (where certain conditions were shown to lead to other conditions). The second technique was explanation building, where the goal was to analyze the case study data by building an explanation about the case. Rival theories were also generated and discussed.

LIMITATIONS

The focus of this research was on computer technical professionals. It did not investigate factors related to technical currency among managers or among people that have less than 15 years experience in the computer profession.

The study was not a comparative study that contrasted good versus bad performers; instead the phenomenon of interest was the process by which technical currency is maintained.

LRN	Learning
LRN-LJ	From Job
LRN-LJP	Learning From People at the Job
LRN-LC	From Coursework
LRN-LM	Method
MGMT	Management
MGMT-E	Environment
MGMT-S	Support
EDUC	Education
EDUC-U	Undergraduate
EDUC-UC	Undergraduate Computer Courses
EDUC-G	Graduate
EDUC-GC	Graduate Computer Courses
EDUC-CPE	Continuing Professional Education
CAREER	Career
CAREER-J	Job Decision
CAREER-JS	Job Start
CAREER-JC	Job Change
CAREER-P	Position Now
CAREER-PP	Previous Positions
INDIV	Individual Characteristics
INDIV-M	Motivation
INDIV-B	Beliefs
INDIV-S	Skills
PROJ	Projects
PROJ-PC	Characteristics
PROJ-PE	Experience
PROJ-PA	Participation
OPPO	Opportunity
OPPO-A	From Academic Qualification
OPPO-W	From Work
FU	Skills Needed Now and in Future
FU-Today	Today's Required Skills
FU-Tom	Skills Needed in Five Years
FU-Need	Skills Lacking Today

FINAL ANALYSIS CODES

FIGURE 4

This research was based on a premise that on-the-job learning from project experiences is an essential part of the solution to maintaining a skilled professional work force to meet government and industry requirements. Educational activities will and must occur at many levels, including college, graduate school, the work site, and through continuing professional education. This research specifically concerned itself with the problem of obsolescence of in-place computer professionals to develop a better understanding of how project experiences contribute to the long-term technical currency of the more than one million computer professionals in the workforce (U.S. Bureau of the Census, 1989).

SUMMARY OF RESEARCH METHOD

The analyses of the cases in the first phase resulted in the propositions being supported generally, but not completely. A preliminary theory was generated that explained how computer technical professionals maintain technical currency over a career. Projects were not shown to be the principal influence. The study propositions were then refined prior to analyzing the information from the second phase's cases.

The analysis of the second set of cases indicated that the revised propositions were strongly supported and added sufficient insight to allow refinement of the emerging technical currency model.

At the end of the third and final phase of the research project, sufficient information had been collected and analyzed to determine the degree of generalizability of the generated theory and to identify plans and recommendations for subsequent, related research.

CHAPTER FOUR

FINDINGS

PURPOSE

The purpose of the study was to gain an understanding of how computer technical professionals maintain technical currency over a career, with particular emphasis on the role of project experiences. Preliminary research indicated that project experiences contributed to, or provided a vehicle for, long-term technical currency.

RESEARCH QUESTIONS

The overriding question that this research investigated was "What is the role of project experiences in helping to maintain technical currency among computer technical professionals?" In order to achieve the purposes of this research the following study questions were established:

1. What is the process by which some professionals maintain currency from project experiences?

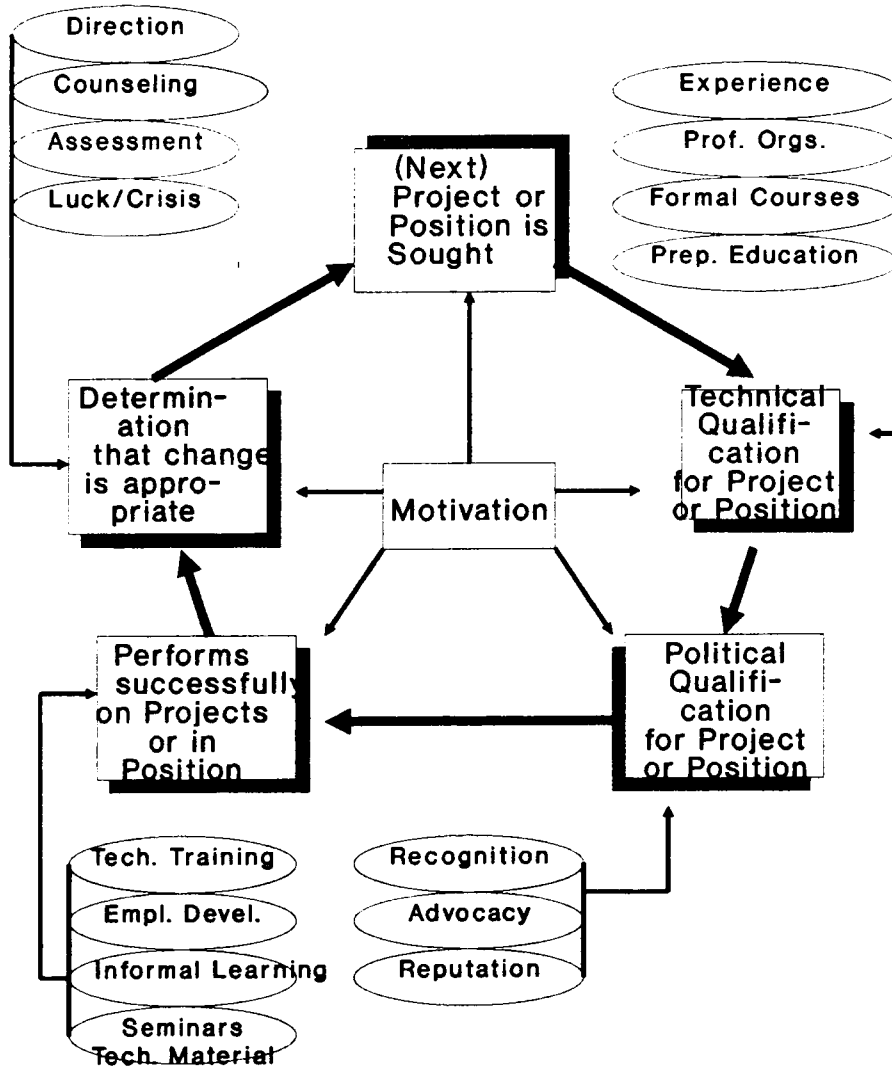
2. How have employees increased the likelihood of learning effectively from project assignments?
3. What organizational practices or other barriers have inhibited an individual's ability to maintain technical currency?
4. How has the individual's formal education contributed to the value of project experiences?

SUMMARY OF KEY FINDINGS

While an essential element, project experiences were not sufficient alone to maintain technical currency. While formal education in preparation for a career was critical, formal coursework did not contribute as significantly as other forms of continuing professional education to maintaining technical currency. The analyses of the cases did not support a premise that people entered formal learning programs to improve their level of technical proficiency or even generally improve their performance. When individuals participated in learning programs, the motivation was to obtain something in the future, such as a new position or to heighten their value to the company. However, technical proficiency improvements could have been realized as a by-product of the coursework. Learning specific technologies on-the-job

and participation in short, focused training episodes, among other learning techniques, were used for direct project contribution or to correct gaps in technical competencies that were viewed as important by the individual. Generally, technical currency was equated with employability.

The explanation that was developed as a result of the three cross-case analyses indicates that individuals expend energy in one or more of five focus areas, depending on their motivation at the time: (a) technical qualification for a project or position; (b) political qualification for a project or position; (c) performing successfully in a position or on a project or projects; (d) determining that change is appropriate; and (e) seeking the next project or position. Figure 5, the Technical Currency Model, depicts the five areas of focus graphically. The model proposes that computer professionals who maintained their technical currency over a career had not done so solely because of involvement on key projects, although that was a part of it. Instead, maintaining technical currency was a continuous process that involved organizational relationships (especially the individual's perceived value within the organization), determinations of project or position alternatives selected and positioned for based on expected benefit, repeated learning episodes, and



TECHNICAL CURRENCY MODEL

FIGURE 5

project accomplishments. Project requirements were opportunities to apply and demonstrate personal capability as much as they were learning experiences. Individual motivation was the driver for career decisions as well as self-directed and self-initiated learning activities.

RESEARCH APPROACH

A multiple-phase, multiple-case study approach was used to describe the role of project experiences in maintaining technical currency, not as a discrete phenomenon, but within the setting of the work environment, considering organizational structures, professional preparation, continuing professional education, and motivation. Preliminary study propositions were established based on preliminary research and literature reviews.

In the first phase of the research, three case studies were conducted with the data incrementally analyzed and tested against the propositions in individual case reports. A preliminary theory was generated in a cross-case analysis report.

In the second phase, three additional case studies were conducted, each analyzed separately. The theory was tested and refined in a second cross-case analysis report,

resulting in the formation of a general Technical Currency Model.

The third and final phase of the research project tested the generalizability of the model. Four additional case studies were conducted involving subjects from different types of organizations. Similarly, data was analyzed and propositions were tested in individual case study reports. A final cross-case analysis resulted in a determination of the generalizability of the model, the model being refined slightly, and plans for future research identified.

STUDY PROPOSITIONS

The analyzed patterns from each case, and collectively in cross-case analyses, were matched to the evolved study propositions, which were:

1. Project experiences contribute to technical currency.
2. Some project experiences are more beneficial in terms of contributing to technical currency.
3. Adequate education in preparation for a career gives some but not all workers the ability to perform initially and adapt (and remain technically current) over time as technology changes.

4. Some people gain more from similar project experiences than others.

5. Assignment to projects involves personal and organizational issues.

6. Characteristics that make a project attractive differ among individuals, although there are several characteristics that are generally accepted as important.

7. Projects that require doing something new are better for maintaining technical currency.

8. Individuals can assess their own degree of technical currency.

9. Projects are desirable for reasons that go beyond technical excitement and perceived learning potential.

10. Individuals engage in multiple types of learning activities, motivated by their view of what is important and expected benefit.

The study propositions were used to move the study in the right direction. Even with established propositions, this research was not tied completely to these particular propositions because the research goal was to discover factors related to the role of project experiences in maintaining technical currency, not merely to test a hypothesis. Thus, the conceptual framework and related study propositions, while not being a pure grounded theory approach, did not prevent the discovery of data. The

preliminary propositions used in the first phase, and refined for the second and third phases, were intended to guide the study, not to limit it.

PHASE ONE FINDINGS

The analyses of the cases in the first phase resulted in the propositions being supported generally, but not completely. A preliminary theory was generated that explained how computer technical professionals maintain technical currency. The study propositions were then refined prior to analyzing the information from the second phase's cases.

PHASE ONE SUBJECTS

The first phase of the research involved subjects (referred to as Subject-1, Subject-2, and Subject-3) from a computer systems and services organization. This type of organization was selected because they employed the greatest number of computer professionals. The four largest firms in this class alone employed over one hundred thousand people in 1991.

PHASE ONE PATTERN MATCHING ANALYSIS

Table 1 summarizes the pattern matching analyses of the individual case studies against the predicted pattern based on the study propositions. Several of the propositions were strongly supported. No propositions were completely refuted, although the analysis indicated that people may not differ as much as believed as to what they think makes a project attractive.

The following subsections provide some of the factual basis for the determination of whether a study proposition was supported (partially or fully) or not supported (refuted or neither supported nor refuted), as reported in Table 1.

Phase One, Proposition One: Project Experiences Contribute to Technical Currency

Subject-1 reported that most learning occurred on the job. He stressed that actually performing led to skill development. He noted that it was not just the technology per-se, but the whole project experience, such as working with project members. Subject-2 reported that learning occurred on the job if he was able to work with people who could teach him how to think and work better. He believed

TABLE 1

PHASE ONE: CROSS-CASE COMPARISONS

STUDY PROPOSITIONS	CASE STUDY NUMBER 1	CASE STUDY NUMBER 2	CASE STUDY NUMBER 3
Project experiences contribute to technical currency	SUPPORTED	PARTIALLY SUPPORTED	SUPPORTED
Some project experiences are more beneficial in terms of contributing to technical currency	SUPPORTED	SUPPORTED	SUPPORTED
Adequate education in preparation for a career gives some but not all workers the ability to perform initially and adapt (and remain technically current) over time as technology changes	PARTIALLY SUPPORTED	SUPPORTED	SUPPORTED
Some people gain more from similar project experiences than others	NOT SUPPORTED or REFUTED	NOT SUPPORTED or REFUTED	NOT SUPPORTED or REFUTED
Assignment to projects involves personal and organizational issues	SUPPORTED	SUPPORTED	SUPPORTED
Characteristics that make a project attractive differ among individuals	PARTIALLY REFUTED	PARTIALLY REFUTED	PARTIALLY REFUTED
Projects that require doing something new are better for maintaining technical currency	SUPPORTED	SUPPORTED	SUPPORTED
Individuals can assess their own degree of technical currency	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED

that other methods of keeping up-to-date are better. Projects that required him to collect facts or involved integrating new technologies were useful for learning on the job. However, on-the-job training was not viewed as a source of knowledge. Subject-3 reported that learning results from association with senior, more experienced staff. Open relationships were considered necessary to enable meaningful discussions among project members. He added that the right type of work environment could promote an employee's taking the time and effort to learn new skills. He stated that there must be time to figure out solutions as well.

Phase One, Proposition Two: Some Project Experiences are more Beneficial in Terms of Contributing to Technical Currency

Subject-1 indicated that the most beneficial projects involved leading-edge technology. He also cited projects that involved design and implementation, of a moderate size, that led to a sense of personal satisfaction. A project that required learning something new, quickly, was also considered beneficial. Subject-2 reported that the most beneficial projects involved integrating new technologies. He also cited projects that provided an

opportunity to work with people who could teach him how to think and work better. Subject-3 reported that the most beneficial projects were those that stretched his abilities to the limit, creating a need to find the right solution. Projects that were not time constrained offered better learning opportunities. Doing things that had not been done before or finding ways to utilize technology to make a difference also provided value.

Phase One, Proposition Three: Adequate Education in Preparation for a Career Gives Some but not All Workers the Ability to Perform Initially and Adapt (and Remain Technically Current) over Time as Technology Changes

This proposition was not supported strongly by Subject-1, although he did report that the general business-related courses taken in college did prepare him well for work. Subject-2 credited his formal education with teaching him how to do research, as well as how to analyze problems, as a result of courses in mathematics. He saw higher education establishing within the person the necessity to keep learning. He saw no substitute for the formal education process, which transformed one's "innate ability into a dogmatically pursued practice." Subject-3 believed that his formal education prior to entering the

workforce provided the foundation upon which to expand, as opposed to learning a specific set of skills. The comparative aspect of this proposition was neither supported nor refuted.

Phase One, Proposition Four: Some People Gain More from Similar Project Experiences than Others

The comparative aspect of this proposition was neither supported nor refuted. Subject-1 reported learning from project experiences in general. Subject-2 and Subject-3 reported learning from certain types of projects and conditions.

Phase One, Proposition Five: Assignment to Projects Involves Personal and Organizational Issues

Subject-1 stated that the earned degree opened doors that gave him the opportunity for employment, and thus, assignment to projects in the first place. He believed that he was the person who decided which projects he worked. He left an employer because the level of task was too low for him. Subject-2 stated firmly that he is primarily responsible for deciding which projects to work. He stated that "if one is not sufficiently motivated to

seek opportunities for his own utilization, then he is a misfit in today's environment." He also cited the need for a responsible organization, but that organizations are lacking in this regard. He felt the need to "sell himself" internally and externally to prevent becoming forgotten, and perhaps, even laid-off. Subject-3 viewed the assignment of projects as a collaborative effort between himself and his superior. He saw that the organization has a role to play in establishing an environment that fosters learning.

Phase One, Proposition Six: Characteristics that Make a Project Attractive Differ among Individuals

Table 2 provides a summary of the "attractive" characteristics that the subjects reported. A "YES" designation indicates that the subject felt that the particular characteristic, or one that is equivalent, led to or made a project attractive. "NO" indicates that the characteristic was not cited by the subject (note: a "NO" does not necessarily mean that the subject did not think that the particular characteristic made a project attractive, only that it was not cited by the subject). "SIMILAR" indicates that the subject cited a characteristic that was similar to the one indicated on the chart.

TABLE 2

PHASE ONE: CHARACTERISTICS OF AN ATTRACTIVE PROJECT

CHARACTERISTICS =====	SUBJECT-1 =====	SUBJECT-2 =====	SUBJECT-3 =====
Ability to learn something new	YES	YES	SIMILAR
Those that stretch your abilities to the limit	SIMILAR	SIMILAR	YES
Start-up involvement	SIMILAR	YES	YES
Start-to-finish involvement	YES	YES	SIMILAR
Involve design and implementation of new features	YES	SIMILAR	SIMILAR
Ability to work on several projects at once (thus, not totally time consuming)	NO	YES	YES
Providing a real benefit or value to the client	NO	NO	YES
Sufficient time to do good work	NO	NO	YES
Pleasant work environment	YES	NO	NO
Involve multiple disciplines and technologies	SIMILAR	YES	SIMILAR

Twenty-three out of thirty possible values in the table are "YES" or "SIMILAR;" thus, these cases indicated that people viewed desirable project characteristics more similarly than predicted.

Phase One, Proposition Seven: Projects that Require Doing Something New are Better for Maintaining Technical Currency

This proposition was uniformly supported. Subject-2 stressed that it is best if the requirement to learn something new must be met quickly. Subject-3 stressed that the person's abilities need to be stressed to the limit and that projects that required creative solutions to problems were also best for learning.

Phase One, Proposition Eight: Individuals Can Assess their Own Degree of Technical Currency

The respondents did not indicate that assessment of their own degree of technical currency was a planned, carefully conducted process. They were, however, able to map their technical capabilities to the job requirements of the present, and the anticipated requirements of their jobs in the future. Subject-1 and Subject-2 did not report any current deficiencies, other than to mention that Artificial

Intelligence may become important. Subject-3 reported that he needed to develop better expertise in software re-engineering, and object-oriented design and implementation.

PHASE ONE CROSS-CASE CONCLUSIONS

It was clear that most of the propositions were supported; however, it was also clear that project experiences were not the sole contributor towards maintaining technical currency. There was a focus on position as much as project, as well as a significant focus on the organization. Personal motivation was also a key variable that seemed to drive career decisions as well as any self-directed and self-initiated learning initiatives.

A finding from the pilot case study was that technical currency, and technical obsolescence, could not be studied as discrete phenomena; instead, the study must encompass the interaction of the individual with his or her environment. This set of case studies supported this finding. While project experiences were certainly important, they were one of several areas of focus for the individuals. Project experiences were as much periods of demonstrating value to the organization as they were learning opportunities.

Formal education was seen as the required basis for subsequent learning and performance. Formal education in preparation for a career had a role in preparing the person for subsequent, continuous learning experiences. Understanding and mastering the process of learning was the critical skill developed in pre-employment formal education. This skill becomes fundamental to maintaining technical currency, because the learning process has to be exercised frequently when preparing for or performing on projects or serving in positions.

PHASE ONE EXPLANATION BUILDING

An exciting form started to take shape during the analysis of this data that was not expected, yet was consistent with the study propositions. The individuals expended energy in one of four areas of focus, depending on their motivation at the time. The four focus areas were:

1. **Qualifying Technically for a Position or Project:**
The energies exerted here included acquiring academic credentials, including preparatory formal education, and advanced degrees. There were no factual data to support a notion that graduate degree programs were undertaken to improve performance.

2. Qualifying Politically for a Position or Project: The term "politically" is used because the attention given to this by the subjects went beyond merely trying to understand their organization; indeed, they took conscious steps to establish and maintain a high degree of acceptability in the organization.

3. Performing in a Current Position or on a Project: When energies were focused on the technical requirement at hand, most of the study propositions came into play. There was great interest in being involved with the right types of projects, from both learning and prestige perspectives. The project experiences, while apparently providing informal learning opportunities, also served as vehicles to demonstrate the individual's value to the organization and as opportunities to exercise their intellectual abilities.

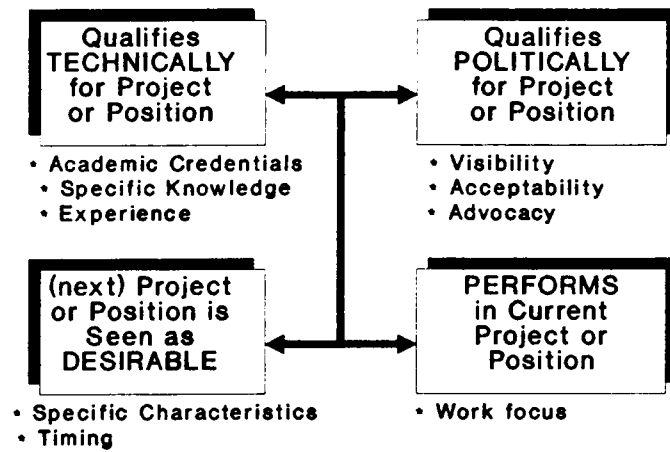
4. Determining that the Next Project or Position is Desirable: Projects were viewed as desirable for much more than the learning potential of the opportunity. Company perception, the opportunity to exercise already possessed skills and intellectual capacity, and the chance to provide something of value to a client were also important considerations. The self-initiated learning, which came in a wide range of varieties, often was related to perceived needs in the future and professionalism, not necessarily for current project requirements.

Figure 6 is a depiction of these four areas of focus, that taken together, created a preliminary model for maintaining technical currency. The emerging theory presented here is that the individual will exert energy and efforts in one of the four areas, depending on his or her motivation at a particular time.

The computer professional who maintains his or her technical currency has not done so because of involvement on key projects, although that is a part of it. Instead, it is a continuous process that involves repeated learning episodes informally on the job or from formal learning programs, organizational relationships, (especially the individual's perceived value within the organization), and determinations of project or position alternatives selected and positioned for based on expected benefit. The driving influence is the individual's motivation.

PHASE TWO FINDINGS

Another set of case studies were conducted and analyzed, selecting subjects (Subject-4, Subject-5, Subject-6) from the same organization, with the same selection criteria. Because the explanation that was developed in the previous phase of the research was complex (i.e., it went beyond a simple explanation that the project



PHASE ONE: PRELIMINARY TECHNICAL CURRENCY MODEL

FIGURE 6

experience was the primary vehicle by which individuals maintained technical currency), and because the coding scheme changed significantly, it was prudent to repeat the analysis and test the explanation without introducing different settings. The research questions had not changed; thus, the interview questions were not modified. The additional propositions that were to be tested were: (a) Projects are desirable for reasons that go beyond technical excitement and perceived learning potential, such as, the chance to enhance standing within the organization, and (b) individuals engage in multiple types of learning activities, motivated by their view of what is important and the expected benefit.

The analysis of the second set of cases indicated that the revised propositions were strongly supported and added sufficient insight to allow refinement of the explanation.

PHASE TWO PATTERN MATCHING ANALYSIS

Table 3 summarizes the pattern matching analyses of the individual case studies against the predicted pattern based on the study propositions. Of the ten propositions, five were completely supported by the three cases; another one was fully supported by two of the three cases (and partially supported by the third), and two were partially

TABLE 3 (PART 1 OF 2)

PHASE TWO: CROSS-CASE COMPARISONS

STUDY PROPOSITIONS	CASE STUDY NUMBER 4	CASE STUDY NUMBER 5	CASE STUDY NUMBER 6	CROSS-CASE ANALYSIS 1
Project experiences contribute to technical currency	SUPPORTED	PARTIALLY SUPPORTED	SUPPORTED	SUPPORTED
Some experiences are more beneficial in terms contributing to technical currency	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED
Education in preparation for a career gives some (not all) the ability to perform initially and adapt over time as technology changes	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED
Some gain more from similar experiences than others	NOT SUPPORTED OR REFUTED	NOT SUPPORTED OR REFUTED	NOT SUPPORTED OR REFUTED	NOT SUPPORTED OR REFUTED
Project assignment involves personal and organizational issues	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED

TABLE 3 (part 2 of 2)

PHASE TWO: CROSS-CASE COMPARISONS

STUDY PROPOSITIONS	CASE STUDY NUMBER 4	CASE STUDY NUMBER 5	CASE STUDY NUMBER 6	CROSS-CASE ANALYSIS 1
Characteristics that make a project attractive differ among individuals	PARTIALLY REFUTED	PARTIALLY REFUTED	PARTIALLY REFUTED	PARTIALLY REFUTED
Projects requiring something new are better for maintaining technical currency	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED
Individuals can assess their own degree of technical currency	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED
Projects are desirable for reasons that go beyond technical excitement and perceived learning potential	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED
Individuals engage in multiple types of learning motivated by their view of what is important	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED

supported. No propositions were completely refuted, although the analysis indicated that people may not differ as much as believed as to what they think makes a project attractive. That was the predicted pattern for that proposition in this analysis; it continued the pattern established in the first cross-case analysis.

The results of the previous cross-case analysis are depicted on the table for reference. The evaluations from the second set of cases were found to be consistent with those of the first set.

The following subsections provide the rationale for the determination of whether the study proposition was supported (partially or fully) or not supported (refuted or neither supported nor refuted), as reported in Table 3.

Phase Two, Proposition One: Project Experiences Contribute to Technical Currency.

Subject-4 reported that employees must learn from their work to stay current with the latest technology. He believed that simple exposure to new tools and products coupled with the requirement to use them led to learning from the job. Subject-5 reported that tackling new assignments, facing new design problems, and learning new tools led to learning from the job. Subject-6 reported

project experiences were the only way to learn how to work with other people. He also stated that learning on the job occurred when something new was being done.

Phase Two, Proposition Two: Some Project Experiences are more Beneficial in Terms of Contributing to Technical Currency

Subject-4 believed that the best projects are those that required him to learn a number of new systems and technologies. Subject-5 said that the best projects are those that required learning a new technology, sub-field, or application. Subject-6 reported that the best projects required something new to be done.

Phase Two, Proposition Three: Adequate Education in Preparation for a Career Gives Some but not All Workers the Ability to Perform Initially and Adapt (and Remain Technically Current) over Time as Technology Changes

The comparative aspect of this proposition was neither supported nor refuted. Subject-4 reported that the speech, technical writing, English, and courses that developed his ability to communicate have been valuable to him. He said that certain programming courses were valuable and have

been used throughout his career. Subject-5 reported that the mixture of basic principles and theory he learned in college gave him a good foundation. For example, in the technical courses, he learned how to develop algorithms and programming skills, but the routine technologies had to be learned on the job. Subject-6 reported that neither his undergraduate nor his graduate program covered specific technologies; however, the graduate level did cover specific approaches to system development.

Phase Two, Proposition Four: Some People Gain More from Similar Project Experiences than Others

The three subjects reported learning from project experiences. The comparative aspect of this proposition was neither supported nor refuted.

Phase Two, Proposition Five: Assignment to Projects Involves Personal and Organizational Issues

Subject-4 reported that some luck was involved in being selected to work on good projects. He also explained that he allowed his resume to be used in a new business effort that resulted in his having to relocate in order to perform on the project. He said that project assignment

was the responsibility of his manager. Subject-5 reported that several factors applied. For example, he could select the projects if he established the requirement with, and arranged funding from, his client. Subject-6 reported that he controlled project assignment because of the good reputation he had established with the firm. He also reported that he earned a graduate degree because that credential was needed to get ahead in his organization. He mentioned that many projects mandate that the persons filling certain positions hold graduate degrees.

Phase Two, Proposition Six: Characteristics that Make a Project Attractive Differ among Individuals

Table 4 provides a summary of the "attractive" characteristics that the subjects reported. The characteristics are listed in order of importance based on the consistency of the subjects' references.

Six of the ten cited characteristics were rated "YES" or "SIMILAR" by three of the four subjects (note: the "fourth" subject here is the summary rating of the first three subjects). Thus, these cases indicated that people view desirable project characteristics similarly, although there are differences.

TABLE 4

PHASE TWO: CHARACTERISTICS OF AN ATTRACTIVE PROJECT

CHARACTERISTICS	CITED BY SUBJECT-4	CITED BY SUBJECT-5	CITED BY SUBJECT-6	FINDING IN 1ST CROSS CASE ANAL.
Start-up Involvement	YES	YES	YES	YES
Start-to-finish involvement	YES	YES	YES	YES
Ability to work on several projects at once (thus, not totally time consuming)	YES	YES	YES	YES
Involve design and implementation of new features	YES	YES	YES	SIMILAR
Ability to learn something new	YES	YES	NO	YES
Involve multiple disciplines and technologies	SIMILAR	YES	NO	SIMILAR
Working with a good team	YES	YES	NO	NO
Important to the company	NO	NO	YES	NO
Those that stretch your abilities to the limit	NO	NO	NO	SIMILAR
Providing a real benefit or value to the client	NO	NO	YES	NO

Phase Two, Proposition Seven: Projects that Require Doing
Something New are Better for Maintaining Technical Currency

The three subjects reported this.

Phase Two, Proposition Eight: Individuals Can Assess their
Own Degree of Technical Currency

Subject-4 reported that he needed to increase his knowledge of the Ada language. Subject-5 reported that he needed to increase his knowledge in object-oriented design. Subject-6 reported that he needed to increase his knowledge of network technologies. He discussed the ramifications of having the stigma of being non-technical (e.g., danger of lay-off).

Phase Two, Proposition Nine: Projects are Desirable for
Reasons That go Beyond Technical Excitement and Perceived
Learning Potential

Subject-4 reported that he joined his current firm because of not feeling that he was a valued member of his previous firm. The firm, in the aerospace industry, seemed to value mechanical and aeronautical engineers over computer software engineers; in fact, he used the term

"second class citizen" to convey his feeling. He cited the Challenger Space Shuttle explosion as the event that caused him to evaluate his career and position. He also reported that he preferred projects that developed something new.

Subject-5's motivation was expressed, primarily, in terms of technical and learning considerations. However, his choice of projects was driven almost completely by his personal interests and efforts (i.e., convincing the client to fund work that he wanted to do).

Subject-6's motivation was expressed, primarily, in terms of the degree of importance attached to the effort, whether from the company's, client's, or his own perspective.

Phase Two, Proposition Ten: Individuals Engage in Multiple Types of Learning Activities, Motivated by Their View of What Is Important and the Expected Benefit

Subject-4 indicated that he relied on: (a) magazines and periodicals to stay informed of new features of technology; (b) learning from doing (i.e., the informal learning from dealing with new products and tools on the job); and (c) coursework that involved teams where he learned how to "bounce ideas off of other people" to see how others approach similar problems.

Subject-5 utilized a wide range of learning methods, including: (a) working on tasks that he is interested in; (b) attending seminars; (c) reading books and periodicals; (d) maintaining a personal technology library; (e) keeping in contact with other technical experts within his firm; (f) designing and conducting training sessions with invited presenters; and (g) utilizing self-conducted training aids, such as video-tapes.

Subject-6 described using the following learning methods: (a) learning from the job itself; (b) exercising skills over time; and (c) learning from people that he respected.

PHASE TWO CROSS-CASE CONCLUSIONS

The evaluations from the second set of cases were found to be consistent with those of the first set. Most of the propositions were supported; however, it was reinforced that project experiences were not the sole contributor towards maintaining technical currency. The same key conclusions from the first phase were again reached, including: (a) there was a focus on position as much as project; (b) there was a significant focus on the organization, particularly the individuals' perceived value of themselves in the organization; (c) personal motivation

was a key factor that seemed to drive career decisions as well as self-directed and self-initiated learning initiatives; (d) formal education was seen as the required basis for subsequent learning and performance. Formal education in preparation for a career had a role in preparing the individuals for subsequent, continuous learning experiences; and (e) understanding and mastering the process of learning was the critical skill developed in pre-employment formal education.

PHASE TWO EXPLANATION BUILDING

The Technical Currency Model that was formed in the cross-case analysis after the first set of case studies was not contradicted; however, this cross-case analysis led to a fifth area of focus. The change to the model was more of a clarification than a correction. Rather than the fourth area of focus being "Determining that the Next Project or Position is Desirable," it provided a better explanation to describe the actions and processes related to that area in two steps, separating the actions, events, or thought process that led to the decision to make a change from the actions involved after the decision was made; specifically:

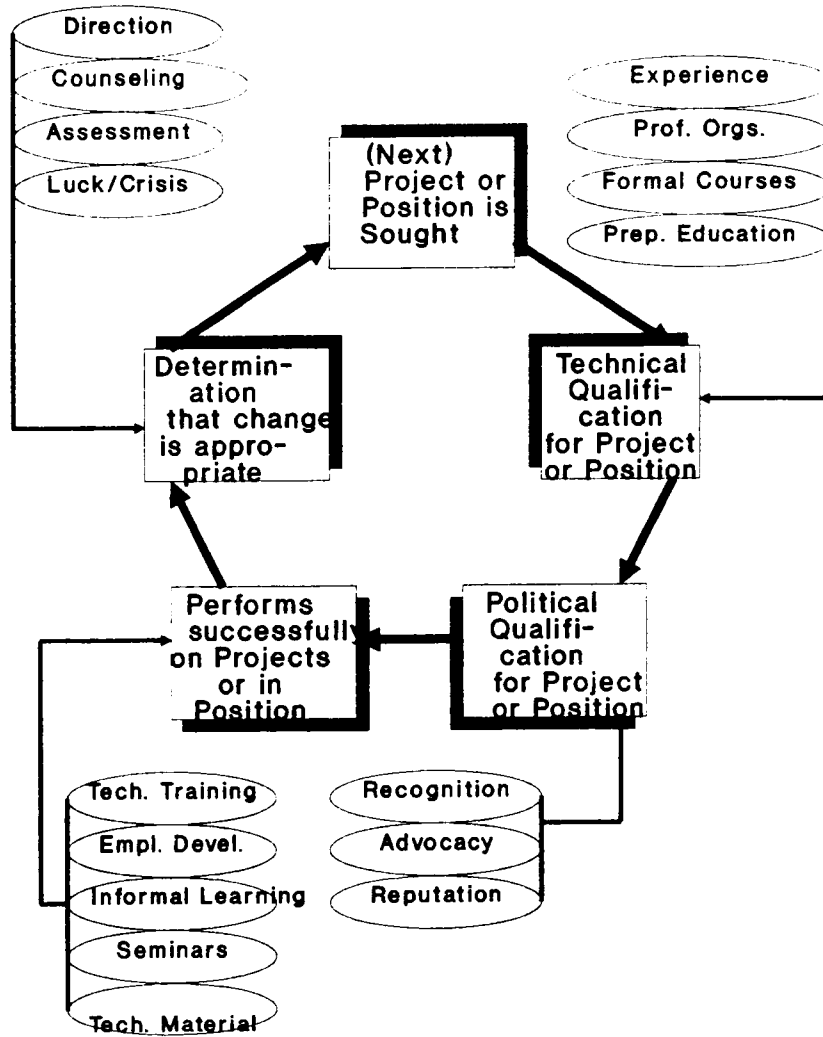
1. Determination that change is appropriate; and
2. (Next) project or position is sought.

The (new) fourth area of focus includes the self-assessments, counseling, management direction, or uncontrollable events that led to a decision to change jobs or positions. The fifth area of focus is less complex. It includes the actions taken by the individual to start the change process (e.g., having a resume included in a proposal for a new project).

The areas of focus are depicted graphically in Figure 7 in order to visualize this model for maintaining technical currency. The emerging theory presented here is that the individual will exert energy and efforts in one or more of the areas, depending on his or her motivation at a particular time. Maintaining technical currency is a continuous process that involves repeated learning episodes informally on the job or from formal learning programs, organizational relationships (especially the individual's perceived value within the organization), and determinations of project or position alternatives selected and positioned for based on expected benefit. The driving influence is the individual's motivation.

PHASE THREE FINDINGS

Phase two of the research project accomplished the goals of the research project. An assessment of the role



PHASE TWO: TECHNICAL CURRENCY MODEL

FIGURE 7

of project experiences was made, and a Technical Currency Model developed to explain the process. Rival theories (presented at the end of this chapter) were discussed and determined that the data did not fit the rival theories. However, the degree of generalizability was still unknown because the subjects considered in phases one and two worked for the same corporation, even though their backgrounds, work locations, and type of work differed. To determine a degree of generalizability of the findings, and to develop more confidence in the theory, a third set of case studies was conducted involving people from different types of organizations. This final set of cases was not based on sampling design (i.e., to build up a larger sample size); it was to establish replications of the theory and determine the degree of confidence in the results.

At the end of the third and final phase of the research project, sufficient information had been collected and analyzed to determine the degree of generalizability of the generated explanation and to identify plans and recommendations for subsequent, related research.

PHASE THREE SUBJECTS

The third phase of the research involved subjects (Subject-7, Subject-8, Subject-9, Subject-10) from computer

product firms and government agencies. The purpose of this phase was to determine a degree of generalizability of the findings.

PHASE THREE PATTERN MATCHING ANALYSIS

Table 5 summarizes the pattern matching analyses of the individual case studies against the predicted pattern based on the study propositions. Of the ten propositions, four were completely supported by the four cases; another four were fully supported by three of the four cases (and partially supported by the fourth), and one was partially supported. No propositions were refuted.

The following subsections provide the rationale for the determination of whether the study proposition was supported (partially or fully) or not supported (refuted or neither supported nor refuted), as reported in Table 5.

Phase Three, Proposition One: Project Experiences Contribute to Technical Currency

Subject-7 reported project experiences forced employees to face and solve new problems. He noted that it would not make sense to spend eight to twelve hours a day at work and not learn from the work itself. Subject-8

TABLE 5 (PART 1 OF 3)

PHASE THREE: CROSS-CASE COMPARISONS

STUDY PROPOSITIONS	COMPUTER PRODUCT FIRM		GOVERNMENT AGENCY	
	CASE STUDY NUMBER 7	CASE STUDY NUMBER 8	CASE STUDY NUMBER 9	CASE STUDY NUMBER 10
Project experiences contribute to technical currency	SUPPORTED	PARTIALLY SUPPORTED	SUPPORTED	SUPPORTED
Some experiences are more beneficial in terms contributing to technical currency	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED
Education in preparation for a career gives some (not all) the ability to perform initially and adapt over time as technology changes	SUPPORTED	PARTIALLY SUPPORTED	SUPPORTED	NOT SUPPORTED
Some gain more from similar experiences than others	NOT SUPPORTED OR REFUTED	NOT SUPPORTED OR REFUTED	NOT SUPPORTED OR REFUTED	NOT SUPPORTED OR REFUTED

TABLE 5 (PART 2 OF 3)
 PHASE THREE: CROSS-CASE COMPARISONS

	COMPUTER PRODUCT FIRM		GOVERNMENT AGENCY	
STUDY PROPOSITIONS	CASE STUDY NUMBER 7	CASE STUDY NUMBER 8	CASE STUDY NUMBER 9	CASE STUDY NUMBER 10
Project assignment involves personal and organizational issues	SUPPORTED	PARTIALLY SUPPORTED	SUPPORTED	SUPPORTED
Characteristics that make a project attractive differ among individuals, although several are generally accepted	PARTIALLY SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED
Projects requiring something new are better for maintaining technical currency	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED
Individuals can assess their own degree of technical currency	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED

TABLE 5 (PART 3 OF 3)

PHASE THREE: CROSS-CASE COMPARISONS

	COMPUTER PRODUCT FIRM		GOVERNMENT AGENCY	
STUDY PROPOSITIONS	CASE STUDY NUMBER 7	CASE STUDY NUMBER 8	CASE STUDY NUMBER 9	CASE STUDY NUMBER 10
Projects are desirable for reasons that go beyond technical excitement and perceived learning potential	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED
Individuals engage in multiple types of learning motivated by their view of what is important and expected benefit	SUPPORTED	PARTIALLY SUPPORTED	SUPPORTED	SUPPORTED

reported project experiences led to improved judgement and to honing of skills. However, he did not explicitly report that he had maintained currency through his project experience; he reported learning valuable lessons from previous project episodes. Subject-9 felt that the job was where one learned the specifics, as opposed to what is learned in the classroom. Subject-10 felt that learning occurred when new technology was used.

Phase Three, Proposition Two: Some Project Experiences are more Beneficial in Terms of Contributing to Technical Currency

Subject-7 said that the best projects were those that involved the initial activities of a project, and were small enough in scope to see the entire process. Subject-8 said that the best projects were those where a lot of new things had to be done. Subject-9 felt that projects involving multiple subjects (i.e., disciplines) were most beneficial. Subject-10 said that projects that involved the latest technology were most beneficial.

Phase Three, Proposition Three: Adequate Education in Preparation for a Career Gives Some but not All Workers the Ability to Perform Initially and Adapt (and Remain Technically Current) over Time as Technology Changes

The comparative aspect of this proposition was neither supported nor refuted. Subject-7 reported that his computer science courses covered specific technologies. His physical science background developed general problem solving abilities. He reflected that the doctoral process that he completed was an excellent preparation for his work. Developing a state-of-the-art research project and defending it to a group of highly qualified individuals showed him what could be accomplished by a single person in a relatively short time. Subject-8 reported that the business courses gave him an understanding of business elements. He did not attribute his ability to remain current to the education; he credited the education to positioning himself for a job in the computer industry. Subject-9 felt that her undergraduate program provided a foundation, upon which to build, as opposed to providing specific expertise. Subject-10 did not feel that his undergraduate education prepared him for a job in data processing, other than math courses.

Phase Three, Proposition Four: Some People Gain More from Similar Project Experiences than Others

The four subjects reported learning from project experiences. However, Subject-8 reported that he learned judgement; he did not indicate that his technical level of proficiency was enhanced. The comparative aspect of this proposition was neither supported nor refuted.

Phase Four, Proposition Five: Assignment to Projects Involves Personal and Organizational Issues

Subject-7 reported that project assignment was done jointly by him and his general manager. He also stressed that he enjoyed working on programs of national significance. He took actions to receive assignments in those areas. Subject-8 reported that project assignment was based on whatever had to be done, based on client requirements. For example, after a sale, he was automatically assigned to that account for start-up. Subject-9 decided on which projects she worked. Subject-10 reported that a collaborative effort with his supervisor led to job assignments.

Phase Three, Proposition Six: Characteristics that Make a Project Attractive Differ among Individuals

Table 6 provides a summary of the "attractive" characteristics that the subjects reported. For reference, the characteristics determined from the previous six cases are included in the table. Five of the ten cited characteristics were rated "YES" or "SIMILAR" by three or four of the four subjects. This is consistent with the previous cases (note: only one new characteristic, national importance, was added as a result of these four case studies). Thus, these cases indicate that while people view desirable project characteristics differently, they generally agree on several characteristics.

Phase Three, Proposition Seven: Projects that Require Doing Something New are Better for Maintaining Technical Currency

The four subjects reported this.

Phase Three, Proposition Eight: Individuals Can Assess their Own Degree of Technical Currency

Subject-7 reported that he needed to better understand the inter-working of office products, because the

TABLE 6

PHASE THREE: CHARACTERISTICS OF AN ATTRACTIVE PROJECT

CHARACTERISTICS	CITED BY SUBJECT-7	CITED BY SUBJECT-8	CITED BY SUBJECT-9	CITED BY SUBJECT-10
Start-up Involvement	YES	YES	YES	YES
Start-to-finish involvement	YES	SIMILAR	YES	YES
Ability to work on several projects at once (thus, not totally time consuming)	YES	SIMILAR	YES	NO
Involve design and implementation of new features	SIMILAR	YES	SIMILAR	YES
Ability to learn something new	SIMILAR	NO	YES	SIMILAR
Involve multiple disciplines and technologies	NO	NO	YES	NO
Working with a good team	YES	NO	NO	NO
Important to the company	NO	NO	NO	NO
Those that stretch your abilities to the limit	NO	NO	SIMILAR	NO
Providing a real benefit or value to the client	YES	NO	NO	YES
National scope	YES	NO	NO	NO

interoperability of office components, such as copiers, fax, phones, and computers would be a major requirement in the 90's. Subject-8 reported that he needed to better understand local area networking and imaging. Subject-9 reported that she needed to better understand object-oriented design. Subject-10 reported that he needed to develop expertise in UNIX, object-oriented programming, database management systems, and PC assembler language.

Phase Three, Proposition Nine: Projects are Desirable for Reasons That go Beyond Technical Excitement and Perceived Learning Potential

Subject-7 strongly stated that the national importance attached to an effort was a motivation for him. He also preferred projects that had real problems to solve and someone to pay for the solution. Subject-8 seemed to enjoy successes, whether a successful project or succeeding within the organization. For example, fighting for and maintaining a budget for product developed was cited. Subject-9 was driven by a need to be challenged, although this need to be creative is not necessarily a need to learn. Subject-10 reported that the importance of the system was a key factor. He recounted an experience where much effort was expended in building a system that ultimately was never used.

Phase Three, Proposition Ten: Individuals Engage in Multiple Types of Learning Activities, Motivated by Their View of What Is Important and Expected Benefit

Subject-7 described using the following learning methods: (a) learning from people, primarily the managers with whom he's worked; (b) reading; and (c) attending conferences and short courses.

Subject-8 felt prepared to tackle new assignments with confidence based upon his record of success and business knowledge. He did not mention learning activities as a way to prepare for future assignments, but did reference learning valuable lessons from: (a) project experiences; and, (b) from people.

Subject-9 expressed a method for learning that she used primarily. Her method was to learn a specific technology, such as a database system, then apply it in a production setting. She also referenced learning from: (a) people, by discussion; (b) attending seminars; and (c) reading.

Subject-10 reported a variety of learning methods he employed, including: (a) reading at home (he subscribed to 50 publications); (b) attending technical symposia; (c) using the latest technology on projects; and (d) learning from people, especially clients.

GENERALIZABILITY

The findings from the third set of cases were found to be consistent with those of the first two sets. Most of the propositions were supported; it was reinforced that project experiences, although important, were not the sole contributor towards maintaining technical currency. Other than the comparative aspects of two propositions that went beyond the data collected by this research, the propositions were supported by these cases; thus, the explanation is generalizable beyond the large services and systems types of organizations.

Although the propositions taken together were well supported, one case did not support the propositions as well as the others, which limits the degree of confidence that can be placed on the generalizability of the findings. That case involved one of the subjects from a computer product firm. It could not be concluded from this case that he learned from project experiences, from a technical proficiency perspective. He also did not indicate that preparatory education was a factor in his ability to remain technically current for 20 years. His case was somewhat an enigma, as he maintained a high level of technical currency and ability (as demonstrated by his job responsibilities, performance, and achievement) but he did not attribute his

technical currency to his preparatory education, project experiences, formal courses, or other forms of continuing professional education. It is possible that the subject believed that his innate ability was what allowed him to maintain a high level of technical currency, and that he inappropriately down-played the significance of his formal and informal learning activities. However, it is also possible that smaller organizations require and value more diversified job activities for the computer technical professional. This possibility places a limit on the generalizability of the theory until further research is conducted to address smaller organizations.

Additionally, because the computer profession has several unique characteristics, such as being technology-focused, where change is inherent and rapid, and being relatively immature, it is not appropriate to generalize findings beyond computer technical organizations.

PHASE THREE EXPLANATION BUILDING

The findings from this cross-case analysis did not alter the components of the model; however, they did serve to reinforce the essential role personal motivation played in all areas, and the different sources and direction of motivation, such as the need to be creative, participate on

programs of national significance, or remained employed. Figure 5, presented earlier, was a graphic depiction of the Technical Currency Model, with a clear indication that motivation is the driving influence.

RIVAL THEORY DISCUSSION

Alternative explanations to maintaining technical currency were not as strongly supported as the Technical Currency Model. Alternative theories are addressed in the following subsections. Each rival theory is discussed in two parts: (a) supporting data for the theory from the actual case data or from other sources is presented; and (b) refuting data from the cases and other sources is provided.

Currency is Maintained by Working on as Many Projects as Possible

The 75 person survey conducted as preliminary research reported that the better rated performers had more project experiences than the poorer rated performers. The researcher anticipated this as a likely explanation prior to conducting the research.

However, the subjects in these cases did not indicate a propensity to move from project to project. The quality of the project, in terms of their preferences, and how the project was viewed by the organization, were equally important. Additionally, the subjects viewed their activities in terms of their position as much as their project involvement.

Cognitive Abilities Determine an Individual's Ability to Retain Technical Currency

The 75 person survey conducted as preliminary research reported that the better rated performers (with technical knowledge being the most important criteria used in determining the performance rating) had self assessments of work capacity and time span of discretion significantly longer than poorer rated performers. Work capacity is the measure of the extent that the person desires to work without feedback. Jaques (1956) proposed that intellectual ability limits work capacity.

This study did not evaluate or attempt to measure the intellectual level or capacity of the subjects. The study was not a comparative study to determine differences between successful and unsuccessful performers. Therefore, this rival theory cannot be dismissed completely based on

the findings of the case analyses. However, this view does not address the dynamics that result from the interrelationships between the individual, the organization, client, colleagues, and the actual work.

Aging Eventually Determines the Individual's Ability to Remain Technically Current

Fluid intelligence (the abilities associated with processing information, drawing inferences, seeing relationships among patterns, and integration) declines with age. This finding was described by the crystallized-fluid model (Horn and Catell, 1966) and has been supported by other researchers, including Brookfield (1988), Knox (1977) and Rybash, Hoyer, and Roodin (1986).

One of the subjects in the study was almost 60 years old. Plus, the researcher has personal knowledge of many technically current computer professionals that are age 60 or older. Moreover, several studies have reported that age and performance are generally unrelated, including McEvoy and Cascio (1989), Rosen and Jerdee (1988), Waldman and Avolio (1986), Fossum et al. (1986), Diener (1984), and Rhodes (1983).

Because the Computer Field Changes Rapidly, Continuing Professional Education in the Form of Formal Coursework is Required to Stay Abreast of the Changing Technology

Miller (1979) proposed that obsolescence resulted from technological change outstripping the education of scientists and engineers. He introduced the notion of the half-life of engineering education, where the content of undergraduate education changed 50% in a seven period.

Two of the subjects maintained a high degree of technical currency without ever participating in formal coursework after starting his career. Continuing learning was found as a necessity in this study. Formal coursework, however, was not as important as other forms of learning activities, such as: (a) learning from people, (b) learning from short courses, and (c) and ad hoc learning.

Effective Management Practices, Including Job Assignment, Maintain Technical Currency Among Its Employees

Kaufman (1979) identified four factors that contributed to obsolescence; among them were organization climate and job assignment practices. Thompson and Dalton (1976) pointed out that the career paths and awards within organizations generally do not address the real concerns of

engineers. Earlier, Dalton and Thompson (1971) reported that engineers with high performance ratings also had job assignments that required use of judgement, skill and knowledge.

The subjects did not report occurrences of their organization taking steps to ensure that they remained technically proficient. References were made frequently to their immediate supervisor in terms of job assignment and to other people that were influences. The respondents reported, in most cases, that they were primarily responsible for job assignment, not the organization.

SUMMARY OF FINDINGS

This research project was initiated to investigate the problem and to develop a model that explained how technical currency can be maintained over a computer technical professional's career.

The multiple-phase, multiple-case research project concluded its first and second phases with the development and refinement of a technical currency model. The analyses reported that individuals expended energy in one or more of five focus areas, depending on their motivation at the time. The developed theory proposes that computer professionals who maintained their technical currency had

not done so because of involvement on key projects, although that is a part of it. Instead, maintaining technical currency required a continuous process that involved repeated learning episodes informally on the job or from formal learning programs, organizational relationships, (especially the individual's perceived value within the organization), and determinations of project or position alternatives selected and positioned for based on expected benefit. Personal motivation, consistent with the expectancy model of motivation, was the driver for career decisions as well as self-directed and self-initiated learning activities. As the third and final phase of this research project, a final set of case studies was conducted to determine the generalizability of the findings.

The findings indicate that the model can be generalized to other types of organizations; however, small organizations may not be supported by the model effectively. Additionally, because the computer profession has several unique characteristics, such as being technology-focused, where change is inherent and rapid, and being relatively immature as an industry, it is not appropriate to generalize findings beyond computer technical organizations.

CHAPTER FIVE
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY OF THE PROBLEM

Technical obsolescence is a serious concern for computer technical professionals, their organizations, and users of their products and services. This research provided a better understanding of process of maintaining technical currency, with special insight into the contribution of project experiences.

STATEMENT OF THE PROBLEM

Technical obsolescence can take on several meanings, such as worn out, lacking, or discarded. For this discussion, the term technical obsolescence refers to people whose work habits, approaches, and technical knowledge have not kept up with the state-of-practice, which itself is generally a few years behind the state-of-the-art. Technical currency, conversely, refers to people who have been able to keep skills current, are considered

by their peers and superiors to be valuable members of the organization, are knowledgeable about the state-of-practice, and are generally knowledgeable about the state-of-the-art. The results of this study added a new dimension to the definition of technical currency: technical currency took on different meanings at particular work locations. Respondents equated technical currency with employability; thus, technically current meant that an individual was up-to-date with a specific technology and skill-set mix valued by their organization.

This research addressed the concern of maintaining technical currency over the long-term. The people of interest in this case were computer professionals -- computer programmers, analysts, system designers, technology specialists (e.g., data base designers, network engineers), software engineers, and other computer specialists.

This study was performed to investigate the process by which computer technical professionals maintain technical currency and prevent technical obsolescence. The contribution of project experiences was a particular area of focus because preliminary research reported a statistical relationship between number of projects worked and performance rating. The overriding question that this research investigated was "What is the role of project

experiences in helping to maintain technical currency among computer professionals?"

IMPORTANCE OF THE STUDY

Given that research had not been published in this specific area, work that provided insight into the problems and potential solutions of technical obsolescence among computer professionals was useful.

This research also shed light on the phenomenon on learning through project experiences. Maintaining technical currency was found to require a continuous process of activities that involved organizational relationships, the individual's perceived value in the organization, constant assessments and evaluations of current and desired project involvement or position, repeated and varied learning episodes, and project experiences.

The results of the study can be used by technical organizations to take steps to ensure that their business practices do not hinder their employees' efforts to remain technically current. Human Resource Development organizations can use the results of this study to support career development planning and counseling as well as by those people charged with designing continuing professional

education programs for computer technical professionals. Most importantly, individual computer professionals can be motivated to learn how to assess their level of currency and develop strategies to be prepared for required levels of technical understanding and proficiency in the future.

LIMITATIONS OF THE STUDY

The focus on this research was on long-term computer technical professionals. It did not investigate factors related to technical currency among managers nor among people with less than 15 years experience in the computer profession.

The study was not a comparative study that contrasted good versus bad performers; instead the phenomenon of interest was the process by which technical currency is maintained.

SUMMARY OF PRELIMINARY RESEARCH

Three preliminary research initiatives were conducted to prepare for this investigation. The first of these preliminary research efforts was a descriptive study that investigated performance ratings and potentially related factors. That effort involved quantitative research and

analysis of a large convenience sample. The second initiative was a follow-up survey which collected additional data about the people, their jobs, and their educational experiences. The third research effort was a pilot case study to develop preliminary research propositions and to determine if case study research was a viable approach to investigate this problem.

CONVENIENCE SAMPLE AND SURVEY

The performance evaluation and administrative records of 505 computer technical professionals were analyzed in a convenience sample to investigate potential relationships between performance ratings and personal, job, and educational attributes. Then, a survey of 75 subjects, selected from the larger sample in the descriptive study, was taken to investigate potential relationships of age, formal education, continuing education, training, and job history with performance rating. The supervisor's rating of performance is not necessarily equivalent to a specific level of technical currency; level of technical knowledge was one of 15 criteria used to develop an overall performance rating. For the personnel in this sample, degree of technical knowledge was one of the more important considerations when assigning an overall rating.

The descriptive research indicated that the most significant statistical relationships with performance rating were the last performance rating (top rated employees were more often top rated the prior year), then years employed with the company (top ranked employees had been with the company longer than others). Age was not shown to be related to performance at the aggregate level. The 75 person survey also showed a relationship of years with the company with performance rating, as well as the employee's self-rating of work capacity and time span of discretion. Time span of discretion is the amount of time that the person has on the job to exercise independent actions. Jaques (1956) stated that the longer the period an employee has to exercise discretion, the greater degree of responsibility is inherent in the job. Work capacity deals with the capacity of the individual, not the job. Work capacity is the measure of the extent that the person desires to work without feedback and direction. The top performers had a significantly different (higher) perception of their work capacity and time span of discretion. The number of projects worked in the last year and last five years were also related to performance rating. College level was also related to performance rating when employees with less than four years employment with the company were excluded from the analyses.

PILOT CASE STUDY

The purpose of this single-case study was to serve as a pilot for the proposed research examining factors contributing to technical obsolescence among computer professionals (and concurrently, the prevention of technical obsolescence). The object of investigation for this case study was an individual, a senior computer scientist with experience in private industry and government service. The inferential process was directed at key events and processes and relationships that occurred throughout his career that affected his ability to maintain a high degree of technical currency. The principal finding from the pilot case study was that it was apparent that project experiences were contributors to maintaining technical currency, either as direct contributors or as vehicles that facilitated continued learning. It was not clear how or to what extent education, on-the-job learning, and continuing professional education contributed to maintaining technical currency.

SUMMARY OF RELEVANT LITERATURE

There were several key findings from the review of relevant literature presented in Chapter Two that parallel

the findings from this research. These findings are discussed in the following sections:

1. Performance does not generally decline with age, but can in situations: While fluid intelligence decreases, crystallized intelligence increases in adulthood. Adults are able to learn as well in their forties and fifties as in their twenties and thirties. This finding was described by the crystallized-fluid model (Horn and Catell, 1966) and has been supported by other researchers, including Brookfield (1988), Knox (1977) and Rybash et al. (1986). One of the subjects in the study was almost 60 years old and the average age of the respondents was almost 45. Plus, the researcher has knowledge of many technically current computer professionals that are age 60 or older.

2. Age is not related to obsolescence: Several studies have reported that age and performance are generally unrelated, including McEvoy and Cascio (1989), Rosen and Jerdee (1988), Waldman and Avolio (1986), Fossum et al. (1986), Diener (1984), and Rhodes (1983). This research did not contradict this finding. The average age of the respondents in this study was almost 45. The respondents, each with at least 15 years of experience, were considered technically current by their organizations.

3. Project experience is an important factor: Kaufman (1979) reported that the nature of the work assigned

affected obsolescence. Similarly, Rothman and Perrucci (1970) proposed that positions that weaken expertise involve narrowed technical activities, such as those involving application over research. The subjects in these cases did not indicate a propensity to move from project to project. The quality of the project, in terms of their preferences, and how the project was viewed by the organization, were equally important. Additionally, the subjects viewed their activities in terms of their position as much as their project involvement.

4. Organizations do not, generally, address key concerns of technical workers: Thompson and Dalton (1976) reported that the reward system in many organizations is designed to provide incentives to move into management, away from technical work. Kidder (1981) reported the same attitude among engineers at a computer hardware manufacturer. Rosen and Jerdee (1988) reported on a comprehensive review of over 60 articles done by Rhodes (1983) where age was positively related to most job attitudes. Among key findings, age was positively correlated to internal work motivation. No significant relationship was indicated between age and commitment. As for attitude, they found that perceptions that the commitment of older workers declines with age are myth, not fact. Several of the respondents in this study reported

that they left organizations when they felt that their talents were not appreciated or utilized appropriately. The respondents, in almost all cases, took steps to ensure that they were prepared and selected for assignment to projects that they desired. This preparation included dealing with superiors and clients.

5. Motivation is a critical factor in maintaining technical currency: Zunker (1990) believed that motivation is the single greatest contributing factor to career obsolescence. Kaufman (1979) identified four factors that contributed to obsolescence; among them was individual characteristics, including motivation. Motivation is a complex concept that attempts to explain why some people initiate work-related behavior and others do not. The major theories can be classified into two categories: (a) content theories that address what motivates people; and (b) process theories that are concerned with how motivation occurs (Hampton et al., 1987). A particular model of a process theory, expectancy theory, was relevant to this study. Hampton (1978) defined the four key elements of expectancy theory: (a) expectancy is a belief about the result that will occur from particular action; (b) valence is the strength of the desire for a result; (c) instrumentality is the degree to which one outcome leads to another outcome; and (d) subjective probability is the

individual's estimate of the likelihood of a particular expectancy or instrumentality. Expectancy theory, generally attributed to Vroom (Hoy and Miskel, 1978), links performance to expected results. The three cross-case analyses reinforced the notion that personal motivation played an essential role throughout the process of maintaining technical currency. There were different sources and direction of motivation, such as the need to be creative, participate on programs of national significance, or remained employed, among others. The expectancy theory of motivation provided an explanation that was fully supported by the data from the cases.

SUMMARY OF THE METHOD

The basic research method employed was qualitative research. A multiple-phase, multiple-case study design was used to describe the role of project experiences in maintaining technical currency, not as a discrete phenomenon, but within the setting of the work environment, considering organizational relationships, professional preparation, continuing professional education, and motivation. Preliminary study propositions were established based on preliminary research, literature reviews, and the researcher's personal experience.

Because the literature review suggested that theories regarding the role of project experiences in maintaining long-term technical currency for computer professionals did not exist, developing theory was a goal of this study. To develop theory based on the collected and analyzed data, procedures prescribed by Glaser and Strauss (1967) were utilized, within an overall study design suggested by Yin (1989) for case study research.

This research project followed a carefully planned iterative process based on Yin's approach to case study research to accomplish explanation building:

1. An initial theoretical statement or initial propositions were made.
2. The findings of an initial case were compared against the propositions.
3. The propositions were revised.
4. The other details of the pilot case were compared against the revisions.
5. The facts of a second, third, and fourth case (and more) were compared to the revised propositions.
6. The process was repeated as necessary.

The first phase of the research project consisted of three individual case studies and a cross-case analysis. This phase of the research resulted in revised analysis categories, slightly modified propositions (including two

new propositions), and an initial theory generated from the analysis. The second phase repeated the process; it resulted in a refined explanation. A third phase was conducted to determine the degree of generalizability that could be attached to the emerging theory. This third set of case studies involved people from different types of organizations. This final set of cases was not based on sampling design (i.e., to build up a larger sample size); it was to establish replications of the theory and help to determine the degree of confidence in the results.

DESIGN QUALITY

The study design featured approaches and mechanisms to achieve proper design quality. The four design quality concerns were reliability, internal validity, construct validity, and external validity.

Reliability was addressed by strict adherence to the case study design; pre-designed questions were used in all cases. When a new class of question was introduced (to collect data related to people, events, or situations that had lasting influences on the respondents), it was asked of all respondents. A case study data base was also maintained. An individual case report was prepared for each case; this report contained a transcription of the

respondent's responses with the researcher's analysis codes noted. The individual case reports also documented the selection approach used to select the respondent for the study and an assessment of how the particular case supported or did not support each of the study propositions.

Internal validity was addressed by using two techniques of analysis, pattern matching and explanation building. Pattern matching involved matching the results of each case to the previously developed propositions. If the patterns coincided, there was good reason to believe that the research design had internal validity (where certain conditions were shown to lead to other conditions). Explanation building, where the goal was to analyze the case study data by building an explanation about the case, followed an iterative path. As case study evidence was examined, the theoretical propositions were revised. The iterative path that this process followed was documented in cross-case analysis reports at the completion of each of the three phases of the research project.

Construct validity was addressed by using multiple sources of evidence; ten subjects from four different organizations were involved in the study. The results of each individual case study, including an assessment of how the particular respondent supported or did not support each

study proposition, as well as a summary of the developed theory, were provided to the respondents for their review.

External validity was addressed in two principal ways. First, replication logic was used in multiple case studies. This process was based on analytic generalization, where the previously developed theory was used as a template to compare results of the case study. Replication occurred when more than one case supported the theory, and importantly, did not support rival theories, which were also explored in this study. Second, the third phase of the study used respondents from different types of organizations than those involved in the first two phases of the study where the theory was initially developed and refined.

SAMPLE SELECTION

Three classes of organizations were included in the study: computer systems and services firms, computer product firms, and government agencies.

The first phase of the research involved three subjects from one of the computer systems and services organizations. This type of organization was selected because it employs the greatest number of computer

professionals. The four largest firms in this class alone employed over one hundred thousand people in 1990.

The second phase of the research again involved subjects from the same organization. Because the theory that was produced in the first phase of the research went beyond a straight-forward conclusion, such as that project experiences led to long-term technical currency, and because the coding and analysis scheme changed significantly, it was prudent to repeat the analysis without introducing different settings.

The cross-case analysis after phase two of the research concluded that: (a) the propositions were supported; (b) the theory developed after the first cross-case analysis held with only slight refinement; (c) the coding and analysis process did not reveal new concepts or dynamics; and (d) rival theories were not supported. To determine a degree of generalizability of the findings, a third set of case studies was conducted involving people from different types of organizations. The third phase of the research involved subjects from computer product firms and government agencies.

Three subjects were selected for each of the first two phases; four subjects were selected for the third and final phase of the research project. All subjects met the following selection criteria: (a) a minimum of fifteen

years of experience in the computer field; (b) classified in a position that had, primarily, technical responsibilities; (c) did not work with the researcher; and (d) was considered technically current (as indicated on a performance evaluation or as reported by a superior in the organization).

The total number of subjects was not imposed prior to the start of the study; however, it was expected that the number would be at least six, and certainly under twenty at most. The rationale for that expected range was based on research design and logistics considerations. First, the research design was interested in replication instead of statistical sampling (Yin, 1989). Correspondingly, based on the preliminary research that included a pilot case study, it was thought that saturation would occur fairly early in the research. Saturation (Glaser and Strauss, 1967) is the point where nothing new is derived from the data. Second, attempting to collect and analyze data from a large number of subjects would have required excessive time and would have provided very little added value, given that this was a theory generating effort as opposed to an experimental design that could have required many subjects representing different characteristics for each setting of interest.

STUDY QUESTIONS AND RESEARCH PROPOSITIONS

In order to achieve the purposes of this research the subjects were asked questions related to the following study questions: (a) What is the process by which some professionals maintain currency from project experiences? (b) How have employees increased the likelihood of learning effectively from project assignments? (c) What organizational practices or other barriers have inhibited an individual's ability to maintain technical currency? (d) How has the individual's formal education contributed to the value of project experiences?

Because of the preliminary research that preceded this study, including the literature review, a conceptual framework existed. This framework identified the main dimensions and factors involved, as well as presumed relationships. The conceptual framework was conveyed in the overall research questions listed previously and in the study propositions that follow:

1. Project experiences contribute to technical currency.
2. Some project experiences are more beneficial in terms of contributing to technical currency.
3. Adequate education in preparation for a career gives some but not all workers the ability to perform

initially and adapt (and remain technically current) over time as technology changes.

4. Some people gain more from similar project experiences than others.

5. Assignment to projects involves personal and organizational issues.

6. Characteristics that make a project attractive differ among individuals.

7. Projects that require doing something new are better for maintaining technical currency.

8. Individuals can assess their own degree of technical currency compared to their peers.

Study propositions direct the study (Yin, 1989). Even with pre-established propositions, this research was not narrowly focused on any particular proposition because the research goal was to discover factors related to the role of project experiences in maintaining technical currency, not to test a hypothesis.

UNIT OF ANALYSIS

The variables of most interest in the study were the individuals and their experiences. The actual unit of analysis for the study was the process by which individuals maintained technical currency, with specific interest on

project experiences. The inferential process was directed at key events and processes and relationships that occurred throughout a career that affected an individual's ability to maintain technical currency.

DATA COLLECTION AND ANALYSIS

The selection of the subjects was purposive in the sense that the organizations were accessible to the researcher. However, the individual subjects were not hand-picked by the researcher. They were either selected by someone in their organization or they responded to an inquiry that was available to a larger group of people. These steps reduced selection bias on the part of the researcher.

Seven categories of questions were used in the study to achieve the research objectives. Several questions supported more than one of the primary study questions. The seven categories of interview questions were:

1. Questions related to education in preparation for a technical career in the computer field (relates to Research Question 4).
2. Questions related to continuing professional education (relates to Research Question 4).

3. Questions related to the value of job assignments in providing opportunities for learning and how this learning occurs (relates to Research Questions 1 and 2).

4. Questions related to organization make-up and operation (relates to Research Question 3).

5. Questions related to informal learning and interpersonal interaction in the workplace (relates to Research Question 3).

6. Questions related to knowledge of technical trends and keeping up-to-date (relates to Research Questions 2 and 3).

7. Question related to key influences (relates to Research Questions 1, 2, 3 and 4).

The "Ethnograph" software package was used to aid in data collection and analysis. "Ethnograph" is a set of interactive computer programs designed to assist qualitative and ethnographic research. It provided automated support to some of the tedious, mechanical parts of the data analysis process. It did not provide any interpretive support. "Ethnograph" is not an expert system. Simply stated, the software replaced the color-coded "3 x 5" index cards that are often used in qualitative research.

The coding process used the codes developed as a result of the pilot case study. There were nine codes:

(a) learning, (b) management, (c) relationships, (d) education, (e) career, (f) environment, (g) problem solving, (h) individual characteristics, and (i) projects. During the pilot case study, sub-categories of these nine principal categories were developed as a result of analyzing the nature of the content. This allowed grouping of related types of information, while still maintaining very specific bins.

Data was analyzed by examining the coded categories for trends or similarities. The methods used to analyze the information included clustering techniques, taking advantage of the hierarchical coding structure, and using the constant comparative method to move from particular to the general concepts. Intuitive inferences were made and then self-examined to prevent bias on the part of the researcher.

During the analysis of the first phase's collected information, the coding structure required changing, as some of the information, and the analysis of that information, did not fit well into the initial analysis codes. During the coding and analysis of these three cases, several codes were added and several eliminated or combined. The codes required only slight modification during analysis of the second phase's information. No changes were required during the third phase.

Two techniques of analysis were attempted. The first was pattern matching, where the results were compared to the previously developed propositions. If the patterns coincided, there was good reason to believe that the research design had internal validity (where certain conditions were shown to lead to other conditions). The second technique was explanation building, where the goal was to analyze the case study data by building an explanation about the case. Rival theories were also generated and discussed.

SUMMARY OF FINDINGS

PHASE ONE FINDINGS

The analyses of the cases in the first phase resulted in the propositions being supported generally, but not completely. A preliminary theory was generated that explained how computer technical professionals maintain technical currency over a career. The study propositions were then refined prior to analyzing the information from the second phase's cases.

Table 7 summarizes the pattern matching analyses of the individual case studies against the predicted pattern based on the study propositions. Several of the propositions were strongly supported. No propositions were

TABLE 7

PHASE ONE: CROSS-CASE COMPARISONS

STUDY PROPOSITIONS	CASE STUDY NUMBER 1	CASE STUDY NUMBER 2	CASE STUDY NUMBER 3
Project experiences contribute to technical currency	SUPPORTED	PARTIALLY SUPPORTED	SUPPORTED
Some project experiences are more beneficial in terms of contributing to technical currency	SUPPORTED	SUPPORTED	SUPPORTED
Adequate education in preparation for a career gives some but not all workers the ability to perform initially and adapt (and remain technically current) over time as technology changes	PARTIALLY SUPPORTED	SUPPORTED	SUPPORTED
Some people gain more from similar project experiences than others	NOT SUPPORTED or REFUTED	NOT SUPPORTED or REFUTED	NOT SUPPORTED or REFUTED
Assignment to projects involves personal and organizational issues	SUPPORTED	SUPPORTED	SUPPORTED
Characteristics that make a project attractive differ among individuals	PARTIALLY REFUTED	PARTIALLY REFUTED	PARTIALLY REFUTED
Projects that require doing something new are better for maintaining technical currency	SUPPORTED	SUPPORTED	SUPPORTED
Individuals can assess their own degree of technical currency	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED

completely refuted, although the analysis indicated that people may not differ as much as believed as to what they think makes a project attractive.

PHASE TWO FINDINGS

Another set of interviews were analyzed, using candidates from the same organization, using the same selection criteria. Because the theory that was produced in the first phase of the research went beyond a straightforward outcome (such that project experiences were the primary vehicle by which individuals maintained technical currency), and because the coding scheme changed significantly, it was prudent to repeat the analysis without introducing different settings. The research questions had not changed; thus, the interview questions were not been modified. The additional propositions that were to be tested were:

1. Projects are desirable for reasons that go beyond technical excitement and perceived learning potential, such as the chance to enhance standing within the organization.
2. Individuals engage in multiple types of learning activities, motivated by their view of what is important and the expected benefit.

The analysis of the second set of cases indicated that the revised propositions were strongly supported and added sufficient insight to allow refinement of the technical currency theory.

Table 8 summarizes the pattern matching analyses of the individual case studies against the predicted pattern based on the study propositions. Of the ten propositions, five were completely supported by the three cases, another one was fully supported by two of the three cases (and partially supported by the third), and two were partially supported. No propositions were completely refuted, although the analysis again indicated that people may not differ as much as believed as to what they think makes a project attractive. That was the predicted pattern for that proposition in this analysis; it continued the pattern established in the cross-case analysis performed after the first three cases. The evaluations from the second set of cases were found to be consistent with those of the first set.

PHASE THREE FINDINGS

Phase two of the research project accomplished the goals of the research project. An assessment of the role of project experiences was made, and a Technical Currency

TABLE 8 (PART 1 OF 2)

PHASE TWO: CROSS-CASE COMPARISONS

STUDY PROPOSITIONS	CASE STUDY NUMBER 4	CASE STUDY NUMBER 5	CASE STUDY NUMBER 6	CROSS-CASE ANALYSIS 1
Project experiences contribute to technical currency	SUPPORTED	PARTIALLY SUPPORTED	SUPPORTED	SUPPORTED
Some experiences are more beneficial in terms contributing to technical currency	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED
Education in preparation for a career gives some (not all) the ability to perform initially and adapt over time as technology changes	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED
Some gain more from similar experiences than others	NOT SUPPORTED OR REFUTED	NOT SUPPORTED OR REFUTED	NOT SUPPORTED OR REFUTED	NOT SUPPORTED OR REFUTED
Project assignment involves personal and organizational issues	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED

TABLE 8 (part 2 of 2)

PHASE TWO: CROSS-CASE COMPARISONS

STUDY PROPOSITIONS	CASE STUDY NUMBER 4	CASE STUDY NUMBER 5	CASE STUDY NUMBER 6	CROSS-CASE ANALYSIS 1
Characteristics that make a project attractive differ among individuals	PARTIALLY REFUTED	PARTIALLY REFUTED	PARTIALLY REFUTED	PARTIALLY REFUTED
Projects requiring something new are better for maintaining technical currency	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED
Individuals can assess their own degree of technical currency	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED	PARTIALLY SUPPORTED
Projects are desirable for reasons that go beyond technical excitement and perceived learning potential	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED
Individuals engage in multiple types of learning motivated by their view of what is important	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED

Model developed to explain the process. Rival theories had been discussed and determined that the data did not fit the rival theories. However, generalizability was in question because the subjects considered in phases one and two worked for the same corporation, even though their backgrounds, work locations, and type of work differed. To determine a degree of generalizability of the findings, and to develop more confidence in the explanation, a third set of case studies was conducted involving people from different types of organizations. This final set of cases was not based on sampling design (i.e., to build up a larger sample size); it was to establish replications of the theory and determine the degree of confidence in the results.

At the end of the third and final phase of the research project, sufficient information had been collected and analyzed to determine the degree of generalizability of the model and to identify plans and recommendations for subsequent, related research.

Table 9 summarizes the pattern matching analyses of the individual case studies against the predicted pattern based on the study propositions. Of the ten propositions, four were completely supported by the four cases, another four were fully supported by three of the four cases, and one was partially supported. No propositions were refuted.

TABLE 9 (PART 1 OF 3)
 PHASE THREE: CROSS-CASE COMPARISONS

STUDY PROPOSITIONS	COMPUTER PRODUCT FIRM		GOVERNMENT AGENCY	
	CASE STUDY NUMBER 7	CASE STUDY NUMBER 8	CASE STUDY NUMBER 9	CASE STUDY NUMBER 10
Project experiences contribute to technical currency	SUPPORTED	PARTIALLY SUPPORTED	SUPPORTED	SUPPORTED
Some experiences are more beneficial in terms contributing to technical currency	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED
Education in preparation for a career gives some (not all) the ability to perform initially and adapt over time as technology changes	SUPPORTED	PARTIALLY SUPPORTED	SUPPORTED	NOT SUPPORTED
Some gain more from similar experiences than others	NOT SUPPORTED OR REFUTED	NOT SUPPORTED OR REFUTED	NOT SUPPORTED OR REFUTED	NOT SUPPORTED OR REFUTED

TABLE 9 (PART 2 OF 3)
 PHASE THREE: CROSS-CASE COMPARISONS

STUDY PROPOSITIONS	COMPUTER PRODUCT FIRM		GOVERNMENT AGENCY	
	CASE STUDY NUMBER 7	CASE STUDY NUMBER 8	CASE STUDY NUMBER 9	CASE STUDY NUMBER 10
Project assignment involves personal and organizational issues	SUPPORTED	PARTIALLY SUPPORTED	SUPPORTED	SUPPORTED
Characteristics that make a project attractive differ among individuals, although several are generally accepted	PARTIALLY SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED
Projects requiring something new are better for maintaining technical currency	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED
Individuals can assess their own degree of technical currency	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED

TABLE 9 (PART 3 OF 3)
 PHASE THREE: CROSS-CASE COMPARISONS

STUDY PROPOSITIONS	COMPUTER PRODUCT FIRM		GOVERNMENT AGENCY	
	CASE STUDY NUMBER 7	CASE STUDY NUMBER 8	CASE STUDY NUMBER 9	CASE STUDY NUMBER 10
Projects are desirable for reasons that go beyond technical excitement and perceived learning potential	SUPPORTED	SUPPORTED	SUPPORTED	SUPPORTED
Individuals engage in multiple types of learning motivated by their view of what is important and expected benefit	SUPPORTED	PARTIALLY SUPPORTED	SUPPORTED	SUPPORTED

CONCLUSIONS

PHASE ONE CONCLUSIONS

It was clear that most of the propositions were supported; however, it was also clear that project experiences were not the sole contributor towards maintaining technical currency. There was a focus on position as much as project, and a lot more focus on the organization than expected. Motivation was also a key variable that seemed to drive career decisions as well as self-directed and self-initiated learning initiatives.

A finding from the pilot case study was that technical currency, and technical obsolescence, could not be studied as discrete phenomena; instead, the study must encompass the interaction of the individual with his or her environment. This set of case studies supported this finding. While project experiences were certainly important, they were one of several areas of focus for the individuals. Project experiences were as much periods of demonstrating value to the organization as they were learning opportunities.

Formal education was seen as the required basis for subsequent learning and performance. Formal education in preparation for a career had a role in preparing the person for subsequent, continuous learning experiences.

Understanding and mastering the process of learning was the critical skill developed in pre-employment formal education. This skill becomes fundamental to maintaining technical currency, because the learning process has to be exercised frequently when preparing for or performing on projects or serving in positions.

An exciting form started to take shape during the analysis of this data, that was not expected, yet was consistent with the study propositions. The individuals expended energy in one of four areas of focus, depending on their motivation at the time. The four focus areas were:

1. **Qualifying Technically for a Position or Project:**
The energies exerted here included acquiring academic credentials, including preparatory formal education, and advanced degrees. There was no support for the notion that advanced degree programs were undertaken to improve performance.

2. **Qualifying Politically for a Position or Project:**
The term "politically" is used because the attention given to this by the subjects went beyond merely trying to understand their organization; indeed, they took conscious steps to establish and maintain a high degree of acceptability in the organization.

3. **Performing in a Current Position or on a Project:**
When energies were focused on the technical requirement at

hand, most of the study propositions came into play. There was great interest in being involved with the right types of projects, from both learning and prestige perspectives. The project experiences, while apparently providing informal learning opportunities, also served as vehicles to demonstrate the individual's value to the organization, and secondly, as opportunities to exercise their intellectual capabilities.

4. Determining that the Next Project or Position is Desirable: Projects were viewed as desirable for much more than the learning potential of the opportunity. Company perception, the opportunity to exercise already possessed skills and intellectual capacity, and the chance to provide something of value to a client were also important considerations. The self-initiated learning, which came in a wide range of varieties, often was related to perceived needs in the future and professionalism, not necessarily for current project requirements.

PHASE TWO CONCLUSIONS

The evaluations from the second set of cases were found to be consistent with those of the first set. Most of the propositions were supported; it was reinforced that project experiences were not the sole contributor towards

maintaining technical currency. These cases also indicated a focus on position as well as project, and on the organization. Motivation was again seen as a key variable that drove career decisions as well as self-directed and self-initiated learning initiatives.

Formal education was seen as the required basis for subsequent learning and performance. Formal education in preparation for a career had a role in preparing the person for subsequent, continuous learning experiences. Understanding and mastering the process of learning was the critical skill developed in pre-employment formal education. This is consistent with the results of the first cross-case analysis.

The Technical Currency Model that was formed in the previous cross-case analysis was not contradicted; however, the analysis led to the definition of a fifth area of focus. This change to the model was more of a clarification than a correction. Rather than the fourth area of focus being "Determining that the Next Project or Position is Desirable," a better explanation to describe the actions and processes related to that area was to separate the actions, events, or thought process that led to the decision to make a change from the actions involved after the decision was made. The two steps are: (a) the determination that change is appropriate, and (b) the next

project or position is sought. The redefined fourth area of focus includes the self-assessments, counseling, management direction, or uncontrollable events that led to a job or position change. The fifth area of focus is less complex. It includes the actions taken by the individual to start the change process (e.g., having a resume included in a proposal for a new project).

PHASE THREE CONCLUSIONS

The findings from the third set of cases were found to be consistent with those of the first two sets. Most of the propositions were supported; it was reinforced that project experiences, although important, were not the sole contributor towards maintaining technical currency. Other than the comparative aspects of two propositions that went beyond the data collected by this research, the propositions were not refuted by these cases; thus, the theory is generalizable beyond the large computer services and systems types of organizations.

Although the propositions taken together were well supported, one case did not support the propositions as well as the others, which limits the degree of confidence that could be placed on the generalizability of the explanation. That case involved one of the subjects from

a computer product firm. It could not be concluded from this case that he learned from project experiences, from a technical proficiency perspective. He also did not indicate that preparatory education was a factor in his ability to remain technically current for 20 years. His case was somewhat an enigma, as he maintained a high level of technical currency and ability (as demonstrated by his job responsibilities, performance, and achievement) but he did not attribute his technical currency to his preparatory education, project experiences, formal courses, or other forms of continuing professional education. It is possible that the subject believed that his innate ability was what allowed him to maintain a high level of technical currency, and that he inappropriately down-played the significance of his formal and informal learning activities. However, it is also possible that smaller organizations require and value more diversified job activities and skills for the computer technical professional. The individual's success in smaller organizations may require greater reliance on broader skills and capabilities. This possibility places a limit on the generalizability of the theory until further research is conducted to address smaller organizations.

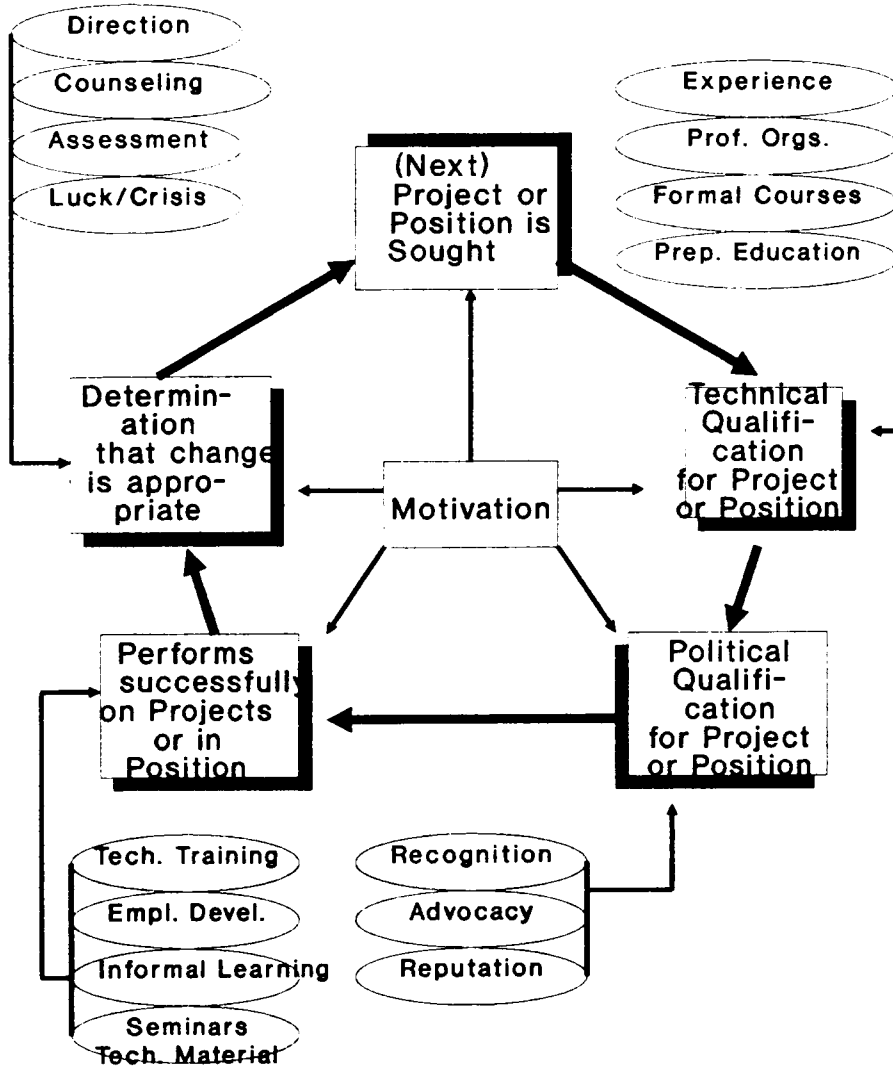
The findings from this cross-case analysis did not alter the components of the theory; however, they did serve to reinforce the essential role motivation played in all

areas, and the different sources and directions of motivation, such as the need to be creative, participate on programs of national significance, or remain employed. The expectancy theory of motivation provided an explanation that was fully supported by the data from the cases. Figure 8 depicts the Technical Currency Model, with a clear indication that motivation is the driving influence.

OTHER CONCLUSIONS

Attractive characteristics of projects differed among individuals; however, there were several characteristics of attractive projects that were generally accepted. They were projects when the individual's participation: (a) included start-up involvement; (b) included start-to-finish involvement; (c) involved design and implementation of new features; (d) provided a chance to learn or do something new, and (e) allowed time to work on other projects as well.

Successful computer professionals utilized numerous learning methods to maintain their technical currency, depending on their focus at the time. Some of the techniques used, in addition to learning from project experiences themselves, were: (a) learning from people (managers and co-workers); (b) reading technical



TECHNICAL CURRENCY MODEL

FIGURE 8

publications and books; (c) attending conferences; (d) taking short courses; (e) attending technical forums; (f) dialoguing with expert personnel; (g) maintaining personal technical libraries; and (h) taking advantage of self-paced, self-directed training, such as video-tapes.

RECOMMENDATIONS FOR TECHNICAL ORGANIZATIONS

The organization has an obligation to share its vision with its employees -- to let them know what is important to the organization today, and what is anticipated to be important in the future. This information sharing must go beyond publishing mission statements and quality policies. Projected technical competencies must be defined. For example, if an organization has elected to down-size its primary computing platforms from a large mainframe-based environment to a distributed network of work-stations on local area networks, perhaps using a client-server architecture, then the computer technical professionals in that organization should be informed of the decision. The information provided to the employees should go beyond merely indicating the technical direction; instead, the expected technical competencies should be identified, such as identifying the particular processors, databases, and networks envisioned. Rather than assuming that new people,

experienced in the particular technology mix, are required to support the transition to the new computing environment, the in-place professional staff should be given sufficient time and support to acquire the new skills.

Listing the required competencies is the minimum action from the organization. An enlightened organization will orchestrate a plan to attain those competencies. This is where Human Resource Development organizations must contribute. The amount of money available for employee development is, in almost every organization, limited. Great care must be taken to ensure that programs are conducted that are productive. This research project indicated that multiple, concurrent, and diverse learning episodes are required to maintain technical currency. Thus, the traditional view of training in the workplace must evolve to recognize, and rely on, all forms of learning, including informal learning from project experiences. The Human Resource Development organization should become the tool by which corporate management moves its organization towards its technical goals.

Corporate management cannot, however, expect the Human Resource Development organization to succeed on its own. Corporate management must create a culture that rewards efforts to remain technically current. Forms of reward start, at the minimum, with education reimbursement

programs. The technical management personnel of the organization require education as well, to become aware of adult learning and group development principles. The technical managers are in the best position to make a difference by serving as advocates and instigators within the organization hierarchy and as facilitators for the development of the professional technical staff. The organization's biggest challenge is to turn its technical managers into development-oriented technical leaders.

RECOMMENDATIONS FOR COMPUTER TECHNICAL PROFESSIONALS

The computer technical professional must face the fact that he or she alone is responsible for his or her own career. They should expect their organizations to be supportive, encouraging, and appreciative of efforts, but not necessarily directing and motivating. The computer technical professional must determine what is valued in his or her environment, be able to assess current deficiencies, and develop a strategy to learn required tools, techniques and technologies.

The individual must realize that technical currency does not mean guaranteed employment from a particular employer. If employment with a particular firm is the paramount goal of the computer technical professional, then

the individual must initiate and maintain actions to understand the organization and his or her role in it. He or she must understand what is required in addition to the raw technical requirements of the position. Areas to consider may include new business development, multiple-discipline expertise, client management skills, technical leadership or attainment of required credentials.

Corporations employ people; they do not adopt them. However, employment obligates the organization to more than paying the negotiated wage. Equally, being an employee obligates the individual to more than performing on-the-job to merely an acceptable level. If a partnership between the individual and the organization is to occur, the individual must make it happen. The better organizations will support the partnership effort.

RECOMMENDATIONS FOR UNIVERSITIES

Higher education institutions that offer formal courses as part of their continuing technical education programs should address all facets of the technical professional's career. Rather than offering a graduate degree in, for example, Information Systems, that includes ten or more courses in areas such as database design, development methodologies, and computer architectures, the

program should also address technical personnel management, adult learning principles, and organization development. Rather than leaving a program with only knowledge of specific technology, graduates should know how to deal with the work environment, to ensure that they are able to apply the technology, and retain and improve their abilities to demonstrate technical skills.

If people attend formal courses or graduate programs more for credential attainment than skill and knowledge development, we have to question the real value of such programs. How many universities follow-up on their graduates twenty, fifteen, ten, or even five years after the attainment of a degree? Universities should conduct research to determine the effectiveness of their programs, and to determine areas for improvement. The role of the university can be expanded to include counseling, consulting, and to some degree, acting as a liaison between organizations and employees. Universities should adopt a long-term view for technical education programs -- views that don't end when the coursework stops.

RECOMMENDATIONS FOR FUTURE RESEARCH

The study provided insight into a complex area. One result of taking such a step is seeing that there is a long

way to go; that was certainly true in this case. The questions that remain are numerous; including:

1. What can the organization really do beyond job assignment practices that can support its employees throughout their technical careers?

2. Can management and individuals apply adult learning principles to protect individuals and organizations from the problems of technical obsolescence?

3. Can corporate sponsored human resource development initiatives or employee initiated adult education programs respond to individual and organizational needs?

4. Which settings are most destructive or most conducive for maintaining technical competence, whether in government (Department of Defense or civilian agencies), non-profit firms, or private industry?

5. Do the sizes, functions, and technical sophistication of the organizations matter? If so, what can be done to offset any disadvantages?

6. How can organizations be confident that their training and development funds are wisely spent? On what principles are such decisions made?

7. Are the right people receiving training, and is the training effective?

These questions cannot be answered until the scope of the problem is better understood. Future research should build upon the results of the preliminary studies and this research project and collect the vital data from a full range of settings. A broad coverage is essential in order to draw conclusions that have relevance across settings. Several research initiatives are appropriate as logical next steps:

1. A study that contrasted good versus bad performers would further test the applicability of the model. A comparative study requiring at least two case studies and a comparison would be an appropriate research approach for this purpose. Another approach would be to use a research methodology similar to this one with subjects that have not maintained an acceptable level of technical currency. This would also provide a good assessment of the generalizability of the Technical Currency Model developed in this study.

2. The scope of the problem needs to be defined. While it is clear that technical obsolescence is a problem, the full extent of the problem is not known. Is it a problem just with those over 40 years of age? Are geographic considerations, perhaps based on the economy, an influence? A quantitative study could be designed that would involve collecting and analyzing data from multiple

industries and locations. Following descriptive analysis techniques, either additional case study or survey research may be appropriate to focus on particular areas.

3. Organizational influences, such as culture, may impact actions of the individual, even though they were not detected as a major influence in this study. An in-depth look at organizational cultures and how job assignment, promotion, and recognition affects employee performance and attitudes may reveal important influences.

4. Counseling programs could be designed and tested to help individuals assess their own level of technical currency and determine if they need to increase their skill level. Different approaches could be designed followed by actual counseling interventions. Then, a learning sequence could be prepared and conducted. As part of the research, an approach to testing the effectiveness of the counseling and follow-on learning would have to be designed and tested in its own right.

CLOSING COMMENTS

This research was based on a premise that education is an essential part of the solution to maintaining a skilled professional work force to meet government and industry requirements. Educational activities will and must occur

at many levels, including undergraduate college education, graduate school, the work site, and through continuing professional education. The Department of Defense-funded Software Engineering Institute (SEI) at Carnegie-Mellon University, as part of its charter, is developing curriculum for undergraduate and graduate degree programs. The SEI effort is focused on skill preparation for a career and education for introduction of new skills (e.g., developing managers from technicians). If successful, the SEI will help alleviate the projected shortage of software engineers by adding new people, with good preparation, into the field. They are not addressing the problem of obsolescence.

This study has made a contribution; it shed light on a complex topic that had not been previously researched. The Technical Currency Model established a framework from which to base subsequent activities. Moreover, the model can be used by computer technical professionals to assess their current status and take steps to ensure that they maintain the level of technical currency required for their environment.

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APPENDIX: REPRESENTATIVE CASE REPORT (#7)

The purpose of this appendix in the dissertation document is to provide one example of a case study report. Ten such reports (one for each respondent) were produced during the conduct of the research project. Three cross-case analyses were also conducted, one at the end of each phase of the research project. Each report summarizes the overall study and results to that point.

INDIVIDUAL CASE REPORT FROM CASE 7

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1.0 OVERVIEW OF CASE 7 REPORT

1.1 Purpose

1.1.1 Purpose of Research Project

The overall purpose of the research project was to gain an understanding of how computer technical professionals can maintain technical currency over a career, with special emphasis on the role of project experiences. Preliminary research indicated that project experiences contribute to, or provide a vehicle for, long-term technical currency.

1.1.2 Relationship to Set of Appendices

The report was produced after the seventh case study, which was the first case study in the third and final phase of the project. Sixteen individual reports comprise the research project data base; references to several of these reports appear in the text of this report. The sixteen reports within the separate Appendices document are:

1. Reports from the Preliminary Research:
 - a. 505 Person Descriptive Study (Appendix 1)
 - b. 75 Person Study (Appendix 2)
 - c. Pilot Case Study (appendix 3).

2. Ten Individual Case Reports (Appendices 4-6, 8-10, 12-15), containing:
 - a. Purpose, Background, Overall Study Design, and Rationale for Selection of Subject
 - b. Case Study Research Design, including Study Questions, Unit of Analysis, and Logic Linking the Data to the Propositions
 - c. Procedures
 - d. Case Study Question Categories
 - e. Storing, Coding and Analysis Approach
 - f. Pattern Matching Analysis
 - g. The transcription of the interview, noted with the Analysis Codes as assigned by the researcher.

3. Three Cross-Case Analysis Reports (Appendices 7, 11, and 16), containing:
 - a. Purpose, Background, Overall Study Design, and Rationale for Selection of Subjects
 - b. Case Study Research Design, including Study Questions, Unit of Analysis, and Logic Linking the Data to the Propositions
 - c. Procedures
 - d. Case Study Questions
 - e. Storing, Coding and Analysis Approach

- f. Cross-Case Comparisons (Pattern Matching Analysis)
- g. Rationale for Analysis Code Changes
- h. Explanation Building (Theory Development)
- i. Rival Theory Discussion.

The research project data base is available by contacting the researcher.

1.2 Background

1.2.1 Research Activities to this Point

The first activity involved descriptive research. The performance evaluation and administrative records of 505 computer professionals were reviewed in a convenience sample. This study was performed in the summer of 1990 to investigate potential relationships between performance ratings and personal, job, and educational attributes.

Second, a survey of 75 subjects, from the larger group, was conducted to investigate potential relationships of age, formal education, continuing education, training, and job history with performance.

Third, a pilot case study was conducted to develop preliminary research propositions and to determine if case study was a viable approach to investigate this problem.

Fourth, a multiple-phase, multiple-case study research project was initiated to further investigate the problem and to develop a theory that explained how technical currency is maintained over a computer professional's career. This individual case study was the first of four conducted during the third and final phase of the research project, involving subjects from different organizations, to further test and determine the degree of generalizability of the explanation developed in the previous two phases of the research project.

1.2.2 Findings from Previous Research Activities

The 505 person descriptive study indicated that the most significant relationships with performance rating were the previous year's performance rating, then years employed with the company. A complete description of the results of this study is presented in Appendix 1.

The 75 person survey also indicated a relationship of years with the company with performance rating, as well as the employee's self-rating of work capacity and time span of discretion. The number of projects worked in the last year and last five years were also related to performance. Complete results of this study are presented in Appendix 2.

The pilot case study was then conducted to examine factors contributing to technical obsolescence considering the total work environment. The principal finding from this research was that it was not clear how or to what extent education, on-the-job learning, and continuing professional education contributed to maintaining technical currency. It was apparent that project experiences were contributors to maintaining technical currency, either as direct contributors or as vehicles that facilitated continued learning. Appendix 3 presents the full description of the pilot case study's purpose, design, and findings.

The multiple-stage, multiple-case research project concluded its first phase with a preliminary technical currency model being developed. The cross case analysis, provided in Appendix 7, reported that individuals expended energy in one of four focus areas, depending on their motivation at the time. The developed theory proposed that the computer professional who maintains his or her technical currency has not done so because of involvement on key projects, although that is a part of it. Instead, maintaining technical currency is a continuous process that involves repeated learning episodes informally on the job or from formal learning programs, organizational relationships, (especially the individual's perceived value

within the organization), and determinations of project or position alternatives selected and positioned for based on expected benefit. The individuals' motivation seemed to drive career decisions as well as any self-directed and self-initiated learning activities. The second phase concluded with an evolved theory that was strongly supported by the second set of cases. The findings from the second cross-case analysis are presented in Appendix 11. As the third and final phase of this research project, a final set of case studies were conducted to determine the generalizability of the findings. This set of four cases involved subjects that worked in different types of organizations.

Documenting the findings from the first of the four case studies conducted for the final phase of the research project is the purpose of this report.

1.3 Overall Study Design

Because the literature review suggested that theories regarding the role of project experiences in maintaining long-term technical currency for computer professionals did not exist, developing theory was a goal of this study. To develop theory based on the collected and analyzed data, procedures prescribed by Glaser and Strauss (1967) were

utilized, within an overall study design suggested by Yin (1989) for case study research. Grounded theory is particularly appropriate when little theory has been developed related to the research problem (Merriam and Simpson, 1989). Qualitative research is appropriate for trying to answer the "why" and "how" questions that are of most interest in this study (Yin, 1989).

1.4 Rationale for Selection of Subject

An individual from a computer product firm (i.e., a different type of organization than that of the first six cases used to develop, refine, and test the technical currency theory) was selected for this case. The respondent was selected because of his accessibility, his association with the type of organization selected for this case, his willingness to support this research, and his technical standing in his organization. He had over 15 years of experience in the computer industry.

2.0 CASE STUDY RESEARCH DESIGN

Because of the preliminary research that preceded this study, including the literature review, a conceptual framework existed. This framework identified the main

dimensions and factors involved, as well as presumed relationships. This is consistent with Miles and Huberman (1984, p. 29): "Bins come from theory and experience, and (often) from the general objectives of the study envisioned. Laying out those bins, giving each a descriptive or inferential name, and getting some clarity about their interrelationships is what a conceptual framework is all about." The conceptual framework was conveyed in the overall research questions listed in section 2.1 and in the study propositions that are presented in section 2.3 of this report.

2.1 Study Questions

In order to achieve the purposes of this research the subject was asked questions related to the following study questions:

1. What is the process by which some professionals maintain currency from project experiences?
2. How have employees increased the likelihood of learning effectively from project assignments?
3. What organizational practices or other barriers have inhibited an individual's ability to maintain technical currency?

4. How has the individual's formal education contributed to the value of project experiences?

2.2 Unit of Analysis

The variables of most interest in this study were the individual and the individual's experiences. The actual unit of analysis for this study, however, was the process by which individuals maintain technical currency, with specific interest on the project experience itself. The subject for this case study was an individual, a senior computer engineer for a high-technology product firm that specializes in integration components and compiler technology. The firm's Ada compiler is one of the leading ones on the market. He was based in Rockville, Maryland.

2.3 Logic Linking the Data to the Propositions

The predicted pattern is to match the pre-established study propositions, which were:

1. Project experiences contribute to technical currency.
2. Some project experiences are more beneficial in terms of contributing to technical currency.

3. Adequate education in preparation for a career gives some but not all workers the ability to perform initially and adapt (and remain technically current) over time as technology changes.

4. Some people gain more from similar project experiences than others.

5. Assignment to projects involves personal and organizational issues.

6. Characteristics that make a project attractive differ among individuals, although there are several characteristics that are generally accepted as important.

7. Projects that require doing something new are better for maintaining technical currency.

8. Individuals can assess their own degree of technical currency.

9. Projects are desirable for reasons that go beyond technical excitement and perceived learning potential.

10. Individuals engage in multiple types of learning activities, motivated by their view of what is important and expected benefit.

Study propositions are used to move the study in the right direction (Yin, 1989). Even with pre-established propositions, this research was not tied completely to these particular propositions because the research goal was to discover factors related to the role of project

experiences in maintaining technical currency, not merely to test a hypothesis. Thus, the conceptual framework and related study propositions, while not being a pure grounded theory approach, did not prevent the discovery of data. The preliminary propositions were intended to guide the study, not to limit it.

3.0 PROCEDURES

3.1 Access to Interviewee

The interviewee was the lead computer engineer at the firm's Washington, D.C. area office, in Maryland. He volunteered to a request to respond to the questions. He has represented his firm on several support projects and has acted as lead technical director on several projects. With 15 years experience, he met the selection criteria for this study. He responded in writing to some questions then met with the researcher to respond to others.

3.2 Resources

The subject was assured that his name and company name would not be disclosed. The interview was transcribed and a PC-based text management system was used to support the collection and analysis of the data.

4.0 CASE STUDY QUESTIONS

To obtain responses from the subject that addressed the study questions, presented in section 2.1, detailed questions were developed and grouped within the following seven categories:

1. Questions related to education in preparation for a technical career in the computer field.
2. Questions related to continuing professional education in the form of formal coursework.
3. Questions related to the value of job assignments in providing opportunities for learning and how this learning occurs.
4. Questions related to organization make-up and operation, including job assignment.
5. Other questions related to informal learning and interpersonal interaction in the workplace.
6. Questions related to knowledge of technical trends and keeping Up-to-date.
7. Question related to key influences.

The actual questions within each group are provided in section 7.0, which contains the interview questions and the responses from the subject.

5.0 STORING, CODING AND ANALYSIS

5.1 Analysis During Data Collection

No analysis was done during the interview itself.

5.2 Post-Data Collection Coding

The coding process used the revised set of codes that resulted from the first cross case analysis.

5.3 Post-Data Collection Analysis

Data was analyzed by examining the coded categories for trends or similarities. The codes established prior to the start of this research project, then modified as a result of the first two phases, did not require modification.

6.0 PATTERN MATCHING ANALYSIS

The primary purpose of the analysis was to determine if pattern matching had occurred. If pattern matching did occur, then the study strengthened its internal validity.

1. Project experiences contribute to technical currency.

SUPPORTED: The subject reported project experiences forced employees to face and solve new problems. He noted that it would not make sense to spend eight to twelve hours a day at work and not learn from the work itself.

2. Some project experiences are more beneficial in terms of contributing to technical currency.

SUPPORTED: He said that the best projects were those that involved the initial activities of a project and were small enough in scope to see the entire process.

3. Adequate education in preparation for a career gives some but not all workers the ability to perform initially and adapt (and remain technically current) over time as technology changes.

SUPPORTED: The subject reported that his computer science courses did cover specific technologies. His physical science background developed general problem solving abilities. He reflected that the doctoral process

that he completed was an excellent preparation for his work. Developing a state-of-the-art research project and defending it to a group of highly qualified individuals showed him what could be accomplished by a single person in a relatively short time.

4. Some people gain more from similar project experiences than others.

NOT DETERMINED AT THIS POINT: The comparative aspect of this proposition was not supported; however, the subject, as cited earlier, did report learning from project experiences.

5. Assignment to projects involves personal and organizational issues.

SUPPORTED: The subject reported that project assignment was done jointly by him and his general manager. He also stressed that he enjoyed working on programs of national significance. He took actions to receive assignments in those areas.

6. Characteristics that make a project attractive differ among individuals, although there are several characteristics that are generally accepted as important.

PARTIALLY SUPPORTED: The comparative aspect of this is reported in the cross-case analysis report presented in Appendix 16. The characteristics described by this subject were: (a) projects that are aligned with a program of national significance; (b) projects where the client has a real problem, and funding to solve it; (c) new projects; (d) start-to-finish involvement if possible; (e) multiple project involvement.

7. Projects that require doing something new are better for maintaining technical currency.

SUPPORTED: The subject reported this.

8. Individuals can assess their own degree of technical currency.

SUPPORTED: The subject reported that he needed to better understand the inter-working of office products, because the interoperability of office components would be a major requirement in the 90's.

9. Projects are desirable for reasons that go beyond technical excitement and perceived learning potential.

SUPPORTED: He strongly stated that the national importance attached to an effort was a motivation for him. He also preferred projects that had real problem to solve, and someone to pay for the solution.

10. Individuals engage in multiple types of learning activities, motivated by their view of what is important and expected benefit.

SUPPORTED: The subject described using the following learning methods: (a) learning from people, primarily the managers with whom he has worked; (b) reading; and (c) attending conferences and short courses.

7.0 TRANSCRIPTION WITH ANALYSIS CODES

The record of the questions and subject's responses, with the researcher's coding decisions noted, is presented on the following pages. A code description is provided at the end; it defines the code names and abbreviations that were used during the analysis of this data.

+ Interview 7. Computer Product Firm	3347	
+ Part 1: education in preparation	3349	
#-INDIV-M		
QQ: When did you start working full-time as a computer professional?	3351	-#
Why?	3352	
	3353	
\$-CAREER-JS		
I7: In 1980, full time, because of my training and my deep interest in the space program.	3355	-\$
	3356	
	3357	-#-\$
QQ: Describe your college education.	3359	
#-EDUC-U		
I7: I have three degrees from college. I have a B.S. in Chemistry from California State University in	3362	-#
	3363	
	3364	
\$-EDUC-G		
Bakersfield, California. I also have an M.S. in Information and Computer Science from the	3365	-#-\$
	3366	
	3367	
#-EDUC-G		
University of California, and I have a Phd in Physical Chemistry with an emphasis on computer modeling of polymers from the University of California.	3368	-#-\$
	3369	
	3370	
	3371	
	3372	-#
QQ: What courses were most valuable in terms of preparing you for work?	3374	
Why?	3375	
	3376	
#-LRN-LC		
I7: The courses in software engineering showed me that software could be developed with structured	3378	-#
	3379	
	3380	-#
#-LRN-LC		
techniques. Computer graphics showed me the business aspects of	3381	-#
	3382	
\$-LRN-LC		
\$-LRN-LM		
computer science. I'd have to say that the Phd process showed me what can be accomplished in a relatively short period of time by a single person. I had to develop state of the art research and defend my	3383	-#-\$
	3384	
	3385	
	3386	
	3387	
	3388	

ideas to a group of individuals	3389	
among the smartest in the country.	3390	
Once that I successfully completed	3391	
this process, I developed	3392	
confidence that has served me well	3393	
in my career.	3394	-§
QQ: Did your education focus on	3396	
specific technologies and	3397	
techniques? Or, do you think your	3398	
education gave you a foundation	3399	
upon which to expand and adapt over	3400	
time?	3401	
I7: My computer sciences courses did	3403	
tend to emphasize specific	3404	
technologies and techniques. My	3405	
Physical Science background seemed	3406	
much more focused towards	3407	
developing general problem solving	3408	
abilities. The combination has	3409	
served me well.	3410	
+ Part 2: Continuing professional	3412	
+ education (formal coursework)	3413	
QQ: Have you taken formal coursework	3416	
from college(s) since starting your	3417	
career?	3418	
#-EDUC-CPE		
I7: Yes, about one course each year or	3420	-#
so since 1980. They have been in	3421	
the area of advanced computer	3422	
science and management.	3423	-#
QQQ: Why were they taken?	3426	
#-INDIV-M		
I7: I took them for general interest.	3428	-#
Although the courses were part of a	3429	
degree program, I did not earn a	3430	
degree from these courses.	3431	-#
QQ: Do you think that these courses	3433	
made you a better performer and	3434	
more technically current? How?	3435	

#-LRN-LC			
I7:	These courses definitely helped me	3437	-#
	in my work performance.	3438	-#
#-LRN-LJ			
QQQ:	What could have substituted for	3440	-#
	the coursework?	3441	
I7:	Some of the courses could have been	3443	
	replaced by more breath in job	3444	
	assignment or in-house training at	3445	
	work.	3446	-#
QQ:	Is it your responsibility to keep	3448	
	up to date, or should your employer	3449	
	tell you what courses to take and	3450	
	plan for them, etc?	3451	
#-INDIV-M			
I7:	Keeping up to date is a partnership	3453	-#
	responsibility between employee and	3454	
\$-MGMT-S			
	employer. Needs for new direction	3455	-#-\$
	should be conveyed by the	3456	
	corporation. Decisions about where	3457	
	the employee can fit into new areas	3458	
	need to be made jointly by employer	3459	
	and employee. Training to support	3460	
	the general thrust of the	3461	
	corporation should also be the	3462	
	responsibility of both the	3463	
	corporation and the employee.	3464	-\$
	+ Part 3: job assignments	3466	
#-LRN-LJ			
QQ:	Do you think learning on the job	3468	-#
	occurs? How?	3469	
I7:	Yes. The learning occurs by	3471	
	forcing the employee to face new	3472	
	problems and solve new problems	3473	
	forced by work changes in work	3474	
	assignments or transitions in a	3475	
	specific project.	3476	-#
#-INDIV-B			
QQ:	Is learning on the job vital to	3478	-#
	keeping up to date?	3479	

\$-LRN-LJ			
I7:	Yes. An employee spends somewhere	3482	-\$
	between 8 and 12 hours a day at	3483	
	work. If learning does not occur	3484	
	during this time, one third to one	3485	
	half of available learning time is	3486	
	wasted. This does not make sense.	3487	-\$-\$
#-PROJ-PC			
QQ:	What are the best types of job	3489	-#
	assignments to have?	3490	
	I believe it is those that involve	3492	
	front-end work, with the customer,	3493	
	with a customer that has real	3494	
	problems and who has the money to	3495	
	solve these problems.	3496	-#
QQ:	Do you like to work on one project	3498	
	from start-to-finish, or on just	3499	
	parts of it?	3500	
#-PROJ-PC			
I7:	I either like front-end jobs or	3502	-#
	short duration total jobs of two	3503	
	years or less.	3504	-#
QQ:	Do you like to work on one project	3506	
	at a time or several at a time?	3507	
#-PROJ-PC			
I7:	I have always been happiest	3509	-#
	juggling 3 or 4 significant	3510	
	assignments.	3511	-#
#-PROJ-PC			
QQ:	What makes a project exciting?	3513	-#
I7:	The ones where the client has a	3515	
	real problem, and money to spend	3516	
	for a solution. I also thing jobs	3517	
	that are aligned with a major	3518	
	national agenda are exciting. The	3519	
	space program has always captivated	3520	
	me because of both the technology	3521	
	and the national importance	3522	
	attached to it.	3523	-#
#-LRN-LJ			

QQ: What types of projects offer the best learning opportunities? Why?	3525	-#
	3526	
I7: Either front-end jobs that are short enough or small enough in scope so that you can see the entire job process in a relatively short period of time.	3528	
	3529	
	3530	
	3531	
	3532	-#
#-LRN-LJP		
QQ: What other factors affect learning from actual work?	3534	-#
	3535	
\$-LRN-LJ		
I7: I would say the type of people that you work with, the types of situations that your project is forced to surmount, and the stage that your program is in. New programs probably offer immediate learning opportunities.	3537	- \$
	3538	-#
	3539	
	3540	
	3541	
	3542	
	3543	- \$
QQ: Describe a job during which you learned something new. How did that happen?	3545	
	3546	
	3547	
#-PROJ-PE		
I7: One of my best learning experiences was setting up the management information system for [an aerospace firm] on the B1 program. The project forced me to deal with databases, distributed processing, and a severely behind schedule, large, government project within a one to two year period. I also introduced personal computers into [aerospace firm] for management applications on the B1 program in 1982 and 1983. This was no mean feat and it gave me training on the issues surrounding the development, training, and maintenance of a new	3549	-#
	3550	
	3551	
	3552	
	3553	
	3554	
	3555	
	3556	
	3557	
	3558	
	3559	
	3560	
	3561	
	3562	
	3563	
	3564	
\$-MGMT-S		
system with top management. Top managers are often the most resistant to change within an organization.	3565	- \$
	3566	
	3567	
	3568	-#- \$
+ Part 4: Organization	3570	

QQ: Who decides the projects that you	3572	
will work on at any point in time?	3573	
 #-CAREER-J		
I7: My work assignments are jointly made	3575	-#
by myself and the company general	3576	
manager that I work for.	3577	-#
 QQ: Does it matter in terms of		
learning on the job and remaining	3579	
technically current how your	3580	
organization is structured and what	3581	
its practices are?	3582	
	3583	
 #-MGMT-E		
I7: Yes. Unless an organization formally	3585	-#
recognizes employee development and	3586	
learning, this area will probably	3587	
not receive a great degree of	3588	
attention.	3589	-#
 #-MGMT-S		
QQ: Does your immediate supervisor	3591	-#
affect your performance or ability	3592	
and willingness to stay up-to-date?	3593	
I7: Not really.	3595	-#
QQ: What do you think an organization	3597	
can do to foster self-improvement	3598	
and continued good performance?	3599	
 #-MGMT-E		
I7: They can share with the employees	3601	-#
the grand vision of the	3602	
corporation. If a long term view	3603	
is developed by top management and	3604	
this view is shared with employees,	3605	
these employees will work with	3606	
management to make this vision	3607	
real. They will also ask for	3608	
training and job assignments that	3609	
will enable them to participate in	3610	
the future of the company.	3611	-#
QQ: What do you think affects the	3613	
ability to remain technically	3614	
competent over an entire career?	3615	

#-INDIV-B			
I7:	I believe that another big driver	3617	-#
	is time. The company needs to make	3618	
	employee education important enough	3619	
	to set aside time to allow the	3620	
	training. This time could be split	3621	
	between employee donated time and	3622	
	company donated time.	3623	-#
	+ Part 5: personal interaction	3625	
QQ:	What are the most important skills	3627	
	that you have developed during your	3628	
	career?	3629	
#-INDIV-S			
I7:	The most important ones are my	3631	-#
	general problem solving skills,	3632	
	organizational skills and	3633	
	motivational skills.	3634	-#
QQQ:	How did you develop them?	3636	
#-LRN-LJ	#-LRN-LJP		
I7:	Primarily from my work assignments	3638	-#
	and from my managers.	3639	-#
QQQ:	How are these skills important in	3641	
	doing your job?	3642	
#-INDIV-B			
I7:	They are important because as a	3644	-#
	technical leader or manager your	3645	
	job depends more heavily on the	3646	
	performance you attain of an	3647	
	organization than solely on your	3648	
	own performance.	3649	-#
QQ:	Are you able to learn from other	3651	
	people?	3652	
#-LRN-LJP			
I7:	I have always learned from the	3654	-#
	company management. I observe each	3655	
	manager, see what they are good at,	3656	
	and I try to emulate their more	3657	
	successful techniques.	3658	-#
QQ:	What position title do you have	3660	
	now?	3661	

#-CAREER-P			
I7:	Currently I am director of the Washington engineering services.	3663	-#
		3664	
QQQ:	Your responsibilities?	3666	
I7:	Responsible for expanding our work in the Washington area, especially within civil government agencies. I report to the President of [the firm].	3668	
		3669	
		3670	
		3671	
		3672	-#
QQQ:	Previously?	3674	
#-CAREER-PP			
I7:	Formally I was the director of the development systems office. I managed a group responsible for Ada interface work, and system description and modeling techniques.	3676	-#
		3677	
		3678	
		3679	
		3680	
		3681	-#
QQQ:	Previous to that?	3683	
#-CAREER-PP			
I7:	I was a department manager leading a group to support the advanced tactical fighter, in the Ada technology area.	3685	-#
		3686	
		3687	
		3688	-#
QQQ:	And before that?	3690	
#-CAREER-PP			
I7:	I was a systems engineer working on a variety of systems that included the space shuttle and [aerospace firm]'s B1 software system.	3692	-#
		3693	
		3694	
		3695	-#
+ Part 6:	Technical trends	3697	
QQ:	What are the critical technologies needed today?	3699	
		3700	
#-FU-TODAY			
I7:	Critical technologies today including establishing the management framework and software technology to enable people to utilize currently available	3702	-#
		3703	
		3704	
		3705	
		3706	

	hardware technology. Current	3707	
	advances in optical storage, image	3708	
	processing, and communication are	3709	
	just beginning to become accessible	3710	
	to the general public. Software is	3711	
	needed to minimize the learning	3712	
	curve and to fully exploit the	3713	
	power that these hardware	3714	
	technologies have already made	3715	
	available.	3716	-#
QQ:	What do you think will be the key	3718	
	technologies, in your organization,	3719	
	five years from now?	3720	
#-FU-TOM			
I7:	Five years from now the	3722	-#
	technologies will center on inter-	3723	
	company and inter-device	3724	
	communication. How to get your	3725	
	phone mail accessible from your	3726	
	computer, for example. Multi-media	3727	
	is big now and will explode in the	3728	
	90's.	3729	-#
QQ:	How will you prepare yourself for	3731	
	the work environment five years	3732	
	from now?	3733	
#-LRN-LM			
I7:	I'm preparing myself by reading and	3735	-#
	attending conferences and short	3736	
	courses.	3737	-#
QQ:	What technologies, for example,	3738	
	UNIX, Ada, C, and object-oriented	3739	
	design, are you least familiar with	3740	
	that you feel are important?	3741	
#-FU-NEED			
I7:	I am least familiar with	3743	-#
	interoperability of office tools.	3744	
	Although I understand computers	3745	
	very well, and offices are	3746	
	increasingly controlled by	3747	
	computers, the phone systems, fax	3748	
	systems, copiers, and document	3749	
	storage devices tend to be closed	3750	
	systems. I don't have a clue to	3751	
	how these devices can interact, but	3752	

	I feel certain that their	3753	
	interaction will usher in an	3754	
	explosion in the 90's.	3755	-#
#-LRN-LM			
QQ:	What role do magazines and other	3757	-#
	periodicals play in helping you on	3758	
	the job?	3759	
I7:	They are relatively important for	3761	
	me.	3762	-#
QQ:	What other approaches help you	3764	
	prepare for and then perform on	3765	
	project assignments?	3766	
I7:	Conferences and short courses.	3768	
QQ:	When you think about your career,	3770	
	certain events or episodes probably	3771	
	stand out in your mind -- things	3772	
	that led to a lasting change in you	3773	
	as a technical professional.	3774	
	Please identify one, two, or three	3775	
	events, situations, or people in	3776	
	your career -- things that made a	3777	
	difference in how you perform or	3778	
	view your job now.	3779	
#-LRN-LM	#-LRN-LJP		
I7:	Working with [company president]	3781	-#
	who eventually went on to run our	3782	
	company. I got to see one of the	3783	
\$-MGMT-E	\$-LRN-LJ		
	best in action. I'd have to say	3784	-#-\$
	that our first lay-off situation at	3785	
	[his firm]. I saw that no matter	3786	
	how up to date you are or how well	3787	
	you perform, that a job is after	3788	
	all a job and you need to be in a	3789	
	position to hawk your skills to	3790	
#-PROJ-PE			
	others will little notice. I'd	3791	-#-\$
	also say, on a more positive note,	3792	
	that acceptance of [their company's	3793	
	hardware description language] as	3794	
	an IEEE standard. Over a period of	3795	
	3 years, I saw how [company]	3796	
	conceived of a new standard,	3797	
	introduced it to the government,	3798	

	and sold it to the IEEE. This	3799	
	standard has been described as the	3800	
	single most important product of	3801	
	the one billion dollar advanced	3802	
\$-LRN-LJ	computer program. I learned that	3803	-\$
	an ego-less approach to technology	3804	
	development can reap tremendous	3805	
	benefit for the corporation and for	3806	
	the general public.	3807	#-\$

CODE NAMES AND ABBREVIATIONS:

LRN	Learning
LRN-LJ	From Job
LRN-LJP	Learning From People at the Job
LRN-LC	From Coursework
LRN-LM	Method
MGMT	Management
MGMT-E	Environment
MGMT-S	Support
EDUC	Education
EDUC-U	Undergraduate
EDUC-UC	Undergraduate Computer Courses
EDUC-G	Graduate
EDUC-GC	Graduate Computer Courses
EDUC-CPE	Continuing Professional Education
CAREER	Career
CAREER-J	Job Decision
CAREER-JS	Job Start
CAREER-JC	Job Change
CAREER-P	Position Now
CAREER-PP	Previous Positions
INDIV	Individual Characteristics
INDIV-M	Motivation
INDIV-B	Beliefs
INDIV-S	Skills
PROJ	Projects
PROJ-PC	Characteristics
PROJ-PE	Experience
PROJ-PA	Participation
OPPO	Opportunity
OPPO-A	From Academic Qualification
OPPO-W	From Work
FU	Skills Needed Now and in Future
FU-Today	Today's Required Skills
FU-Tom	Skills Needed in Five Years
FU-Need	Skills Lacking Today

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