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ABSTRACT

The training of computer users is becoming increasingly important to all industrialized nations. This study examined how individual differences (e.g. ability and gender) may affect learning outcomes when acquiring computer skills. Subjects (N=347) were college students who took a computer literacy course from a college of business administration designed to allow the student to be more efficient in a work environment employing computers. The course involved both lecture and hands-on practice with computers. Students were divided into three groups based on their grade point averages and whether they had taken a computer course previously. Analyses of the data indicated that women tended to be more successful than men in transforming practice effort with the computer into higher learning performance for various ability groups. Lower ability students benefited primarily from attending an earlier computer science class in the hands-on section of the subsequent computer literacy course for office settings. The results obtained question some assumptions made in the literature about what constitutes efficient training for acquisition of computer skills. (Author/ABL)

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INDIVIDUAL DIFFERENCES AND ACQUIRING COMPUTER LITERACY:

ARE WOMEN MORE EFFICIENT THAN MEN?

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INDIVIDUAL DIFFERENCES AND ACQUIRING COMPUTER LITERACY: ARE WOMEN MORE EFFICIENT THAN MEN?

ABSTRACT

This paper examines how individual differences (e.g., ability and gender) may affect learning outcomes when acquiring computer skills for the office. Analyses of the data indicate that women tend to be more successful than men in transforming practice effort with the computer into higher learning performance for various ability groups. Lower ability students benefit primarily from attending an earlier computer science class in the hands-on section of the subsequent computer literacy course for office settings. The results obtained question some assumptions made in the literature about what constitutes efficient training for acquisition of computer skills. Implications for future research and practitioners are outlined.

INDIVIDUAL DIFFERENCES AND ACQUIRING COMPUTER LITERACY: ARE WOMEN MORE EFFICIENT THAN MEN?

The training of computer users is becoming increasingly important to all industrialized nations. Many employment opportunities for future generations created through the introduction of computer based technologies, and the successful implementation of technology into organizations--because only the efficient use of technology really warrants the huge financial investment required--depend on this training. Unfortunately, workers themselves often complain of inadequate training, and it may be this which causes them to accuse new technologies of lowering the quality of work life (e.g., Gutek & Bikson, 1985).

Past research has usually concentrated on primary and high school pupils who attend elective courses, or on computer science majors at university. Moreover, training has been short term (usually less than four hours) and technically focused. This raises three issues: (1) Subjects are usually taught more declarative knowledge (knowledge about something) than procedural knowledge (how to do something). Hence, while these students may know something about the computers themselves (e.g., technical specifications), employees may require more knowledge about how to use a computer efficiently on their jobs. (2) Students attending an elective course can be assumed to be interested in the subject if not being actual computer "buffs"; in contrast, many employees may not be interested in computers and, more importantly, resist their introduction or expanded use in the workplace. (3) Short term training (e.g., up to one working day to learn a software package such as Lotus) may not provide enough time for less able students to practice and, thereby, possibly close most of the

performance gap to their more able peers. Furthermore, lower ability students may experience cognitive overload, thereby reducing retention and comprehension of the material taught (cf. Klein, Hall, Laliberte, Chapter 1 in this book).

This chapter examines relevant research and documents a series of studies which seek to determine the most efficient training strategies for individuals with different levels of academic ability by identifying factors that influence their acquisition of computer literacy. Three components of training--method, content, and assessment- are discussed before testing their applicability and usefulness in developing an efficient computer training program.

What makes this series of studies especially interesting is the fact that data reported herein will contradict some earlier research in three ways: (1) women tend to be higher performers than their male counterparts; (2) previously acquired technical skills do not, necessarily, sufficiently improve learning performance in a course teaching computer skills for the office to warrant the time effort required, and (3) the recent trend to offer short-term courses for acquiring computer skills may be detrimental to efficient acquisition of computer skills.

LITERATURE REVIEW

Before reviewing the literature it is necessary to outline what **end-user computing** (EUC) means in this context. Broadly defined, EUC encompasses the application of information technology (often a networked PC) by employees who do not necessarily consider themselves to be computer specialists. EUC has spread far beyond the data processing computer scientists (Panko, 1987); today's end-users need training which enables them to make efficient use of the computer hardware and various software without being technical specialists.

How Efficient are Various Training Methods?

Literature on the efficiency of computer training has produced conflicting results and has left more unanswered questions than definitive statements. Existing computer training methods use lecture formats, practical "hands-on" methods, or combinations of the two, but questions remain concerning the relative ficiency of these methods towards improving the acquisition of computer skills (Burke & Day, 1986).

Training in an organizational context may be defined as any organizationally-initiated procedure which is intended to foster learning among organizational members (Hinrichs, 1976). Learning, similarly, may be thought of as a process by which an individual's pattern of behaviour is altered in a direction which contributes to organizational effectiveness (Hinrichs, 1976). Training should use several methods to teach skills (Burke & Day, 1986). The lecture approach is one of the most traditional methods for presenting information, usually involving a carefully prepared oral presentation on a subject by a qualified individual (Reith, 1976). The content of lecture-based training is conceptually and theoretically focused, while drill-and-practice training emphasizes application of concepts and theories to solve problems in a possible work setting (see also the section entitled The Economics of Training and Time Usage).

Computer skills. Most research has not defined what type of computer skill the individual is supposed to acquire in a training program. In a recent review of human motor skills research, Adams (1987) emphasized the need for establishing a working definition of skills. For the treatment of skill acquisition in this chapter, the skeleton of Adams' three defining criteria has been borrowed: "(1) Skill is a wide behavioral domain. (2) Skill is learned.

(3) Goal attainment is importantly dependent upon motor behavior" (Adams, 1987, p. 42).

This paper primarily focuses on training efforts by firms which are intended to provide their workforce with the computer skills needed to make efficient use of new technology. Of the three levels of end-user skills which have emerged, only the first two, which are needed to do well on computer mediated work in office settings, will be addressed. The skills to be acquired may include employing the appropriate software for simple clerical (technical) tasks, such as business correspondence, report writing and spreadsheets, and for more complex tasks, such as computer-aided drafting, design and production scheduling, at the first level. The second level skills to be acquired include using software competently and understanding the possibilities of a computer or information system. The third level of computer literacy, which necessitates using development software such as D-Base III to develop sophisticated applications, is not required by the average office worker.

The first and second levels of computer literacy are dominated by the individual acquiring procedural knowledge (how to do something). Computers are usually introduced into the workplace without changing job content and structure, thereby leaving the type and level of declarative knowledge (knowledge about something) required to perform the job largely unchanged (Bikson, Gutek & Mankin, 1987).

The rationale for investigating skill development and enhancement in office technology is twofold: (1) Computer skills are necessary for efficient technology use by employees (Gattiker, 1988a). (2) More and more organizations and government agencies are spending vast amounts of money on skill training in the end user computing domain hoping to facilitate achievement of efficient use

of information technologies (Leontief & Duchin, 1986; Panko, 1987).

Skill acquisition. Recent research has stressed that skill acquisition is ordinarily a continuous process with stages or phases describing the different aspects of the learning process (Adams, 1987). More recent research has centered in perceptual learning. This topic in perception theory is called controlled versus automatic processing, and its protagonists have been Schneider and Shiffrin (Schneider & Shiffrin, 1977; Shiffrin & Schneider, 1977). These authors present skill acquisition in three phases, namely (1) controlled processing, (2) mixed controlled and automatic processing, and (3) automatic processing.

Automatic information processes are characterized as fast, effortless (from a standpoint of allocation of cognitive resources), and unitized (or proceduralized) in such a way that they may not be easily altered by a subject's conscious control; they may often allow for parallel operation with other information processing components within and between tasks. Automatic processes are operations which are developed through extensive practice under consistent conditions, and include skilled behaviours as diverse as typing and skiing. As these processes become automatic, the cognitive or attentional resources devoted to the task are reduced. In contrast, controlled processes are necessary when task/test requirements are novel, and when the subject may not be able to internalize the consistent aspects of the task. Controlled processing is typically slow and difficult because performance is limited by the amount of cognitive resources available to the individual. An example of an activity requiring controlled processing might be writing a report on a computer using a software package one is not truly familiar with, a resource intensive task which does not allow for much automatic processing (Ackerman, 1987). However, often a task may be a mixture of controlled and automated processes. For

instance, writing a memo using the appropriate software requires some automated processes (e.g., loading and starting up software, typing appropriate headings and an ending), while writing the content itself is ing efforts of four hours or less (e.g., Bayman & Mayer, 1988; Gist, Rosen & Schwoerer, 1988) may not have taken this important process into account, thus limiting generalizability of the results.

Content of training. Tornatzky (1986) stated that narrow skills training may be insufficient, and it seems to be true that computers are most successfully used in the workplace when employees understand the principles behind their machines as well as know how to operate them in a relatively narrow ing efforts of four hours or less (e.g., Bayman & Mayer, 1988; Gist, Rosen & Schwoerer, 1988) may not have taken this important process into account, thus limiting generalizability of the results.

Content of training. Tornatzky (1986) stated that narrow skills training may be insufficient, and it seems to be true that computers are most successfully used in the workplace when employees understand the principles behind their machines as well as know how to operate them in a relatively narrow technical sense. Today's business graduate should be skilled not only in word processing, computer-aided statistical analysis, and spreadsheet and data base management, but also--and more importantly--in the basics of a computer language (Jones & Lavelli, 1986). Essentially, the student should be able to program the computer as well as using it as a tool (Taylor, 1980).

The efficiency of training will also depend on the level of task-complexity. Increasing the latter places a greater load on the cognitive and attentional apparatus, thus it will take the individual longer to attain an "understanding" of the task requirements. Only after one fully understands the task can one start improving performance speed and accuracy through practice.

If the task is consistent (i.e. within task components or between task components) as is the case for a telephone operator entering purchase orders into the computer system, the individual will need less time to master the task and soon acquire a higher performance speed.

Evaluation of training. Assessment of the individual's success in learning the applications discussed above is necessary either during, or at the end of, the training process (Burke & Day, 1986). This is typically accomplished either by using reference ability measures (usually paper-and-pencil tests) to measure the theoretical and technical knowledge taught to individuals, or by using learning measures (usually simple information processing procedures designated as tasks) to measure the performance level attained by the individual in working with the computer (cf. Ackerman, 1987). Theoretically, tests and assignments give the feedback the student needs to improve learning; additionally, they should also encourage students to be creative in problem solving to a level which goes beyond that strictly required by the formal parts of the educational process.

The Economics of Training and Time Usage

For the organization, shorter training times mean fewer dollars spent per trainee, especially when the trainee is paid while learning; however, acquiring the necessary computer skills in the shortest time possible also benefits students, as this will enable them to enter the job market more quickly. As outlined in the previous section, time efficiency, unfortunately, is often dependent upon the type of skill to be learnt (procedural versus declarative knowledge), and the content of training (routine vs. non-routine tasks). Continuous tasks do, therefore, allow a higher degree of automation in performing a computer-mediated task than a non-routine task. In the section below we will

specifically discuss how time efficiency may also be affected by individual differences such as gender, ability and motivation.

Individual Differences and Skill Acquisition

Individual differences have been of interest to educators and trainers for some time. Differences may be based on sociodemographic factors (e.g., gender), ability, or the level of motivation by the individual to acquire the skill.

Individual differences and learning. For computer training, research reports that homogeneous ability groups require less training time. Higher ability individuals reduce their time required to achieve acceptable performance levels considerably if they are grouped with similarly able peers (Dossett & Hulvershorn, 1983). However, learning opportunities decrease for lower ability groups if ability grouping is used and, most importantly, the latter group is likely to be taught less than the high ability group. Hence, performance differences based on ability are reinforced by ability grouping rather than minimized (Sorensen & Hallinan, 1986). From an instructional point of view it is more advantageous to refrain from ability grouping as all participants should achieve a similar level of performance. The latter is more likely if one refrains from ability grouping (Sorensen & Hallinan, 1986).

Most research about computer training has concentrated on higher ability groups (Butcher & Muth, 1985). The individuals who formed these groups were typically high school students attending an elective computer course, and thus represent a high interest group (e.g., Anderson, 1987). If all end-users were members of such a group, it would be quite easy to train them, but many individuals who will have to use computers may find them uninteresting or even intimidating. Organizations and educational institutions, therefore, have to

be concerned with time-efficient methods of training for less able and less enthusiastic students (Dossett & Hulvershorn; 1983; Gattiker & Paulson, 1987).

Transfer and access of knowledge. It is easy to assume that exposure to traditional computer literacy will facilitate the learning of "new" computer skills, and research has indicated that such a transfer of knowledge may indeed allow the individual to improve learning efficiency (Bandura, 1977; Thorndike, 1913). Increasing the degree of positive transfer-of-training from previous experience is hypothesized to allow learners to commence a task at a performance level which is superior to novice learners (Ackerman, 1988). Furthermore, previous computer exposure may also lead to a certain level of familiarity with the technology, which may also facilitate learning.

Exposure to traditional computer literacy often occurs in an academic setting; however, if learning about computers is embedded in social situations people naturally encounter once they leave the classroom, the future access of information learned in these situations will be even easier (Bransford, Sherwood, Vye & Rieser, 1986). Hence, EUC training should facilitate later access of the concepts and theory taught by enabling the student to apply these in simulated real-life situations (e.g., using case studies, business like problem-solving and simulation games).

Gender differences. Research indicates that gender differences in computer literacy do exist (e.g., Johnson, Johnson & Stanne, 1986; Anderson, 1987). Johnson et al. (1986) reported that females performed best in a non-competitive learning environment for computer training, and suggested that, when trying to solve problems with a computer, they seemed more able to transfer knowledge gained in other subjects than males.

Two issues are raised when reviewing the literature. First, most studies

assessing gender differences in computer education use primary and high school students attending elective courses (Hebenstreit, 1985). Research indicates that females in such cases are a small minority and have higher levels of mathematic ability and interest in computers than most of their female peers (e.g., Campbell & McCabe, 1984). Thus, these females may be behaving against sex role stereotypes and may not be representative of the population (Vollmer, 1986). It may be more useful, however, to study groups who are not necessarily interested in computers, and who may even be apprehensive, thereby providing a sample which is more representative of the larger population.

The second issue is that most research assesses learning performance indirectly when comparing females with males (e.g., Chen, 1986); attitudes are measured at the beginning or end of training. Other research measures programming skills when comparing males with females. For example, Anderson (1987) measured how well females did in problem analysis and organizing the structure and flow of data for a practical computer program solution in comparison to males. However, computer literacy for end-users in an office setting is generally neither taught nor assessed in such courses. Hence, Bikson and Gutek (1983) claim that existing work is of little use to managers who must train end-users for a less technical computer environment.

The above suggests that the differences recorded between males and females may be due largely to the learning environment and the type of training provided. Theory has also argued that differences may be due to lower self-expectancy by women (Vollmer, 1986) and sex-roles which convince women that computers are too technical for them to understand, causing them to shy away from such technology (Campbell & McCabe, 1984). Hence, less technically focused training which makes it clear to the student that computer literacy is a necessary tool for career

success, may eliminate differences based on gender by encouraging women to exert effort and acquire the skills (Gattiker, 1988b; Eden & Ravid, 1982; Jones & Lavelli, 1986). Such training could in turn set women on an equal footing with men.

Individual motivation and transfer of knowledge. Skill acquisition is, of course influenced by the subject's motivation. A highly motivated individual may put more effort into acquiring computer skills than others, thereby compensating to some degree for lower ability. Complex tasks require some perseverance to improve performance. For instance, Keith (1982) found that lower ability students who practised three hours per week achieved the same grades as average ability students who spent no time on homework. Hence, allocating insufficient learning time has a direct negative effect on achievement (Gettinger, 1985).

Practice time necessary to attain higher performance levels may differ between various groups. For example, students with previously acquired computer skills could be more effective in transferring learning into higher performance. Moreover, time effort may be more helpful for acquiring some skills (e.g., using the computer to do a job-like task) than others, such as complex and abstract tasks (e.g., lecture-type training used to explain technical and logical concepts of computer and information systems). This being the case, it is necessary to learn how much extra practice time is required for lower achievers to attain competency levels similar to those attained by their more able peers to acquire procedural knowledge as well as declarative knowledge about computers (Dossett & Hulvershorn, 1983).

Summary

Based on our discussion, the following shortcomings of past research can

be identified and listed in order of importance: Past research has primarily concentrated on (1) computer "buffs", (2) short term training efforts, and (3) teaching technical skills (e.g., programming) which may not be the most important ones for an employee doing computer-mediated work in the office. This suggests that further research should be done using subjects who are not necessarily interested in computers, and are being trained for the office setting. Moreover, intermittent training (e.g., attending one to two hours of training every week over several months) should be tested to see if automating some task components needed to perform a computer-mediated job may, in fact, reduce differences in learning performance based on ability and gender.

SERIES OF STUDIES

The series of research studies we will examine were carried out at a Western Canadian university and evolved over the course of several years. This series came about after the university's Faculty of Management established both a core course teaching computer skills and a computer lab in the fall of 1982. Before 1982, students majoring in business administration, in order to fulfill graduation requirements, were required to take a course offered by the Department of Computing Science which instructed students in traditional computer literacy, algorithms, BASIC programming and other technical skills. The management faculty, however, felt that this course ignored skills needed to work with computers in office settings, and when the Faculty of Management came into existence, it established a EUC course taught by the school's own faculty.

This series of studies was started during Summer 1985, six teaching semesters after establishing the computer lab and the course. The first few semesters were used to fine tune and to adapt the most efficient teaching

techniques. Starting the series of studies in the summer of 1985, therefore, guaranteed some stability between semesters, since the novelty of the course had worn off and the teaching methods had proven efficient in equipping students with computer literacy. The researcher's responsibility was limited to independent ·· iation and he was not involved in designing or teaching the class. The studies used different sub-samples (i.e., a randomization procedure was used for su -sample selection) of the total population.

Subjects

The EUC course is usually taken by third and fourth year undergraduate management students and is designed to impart a degree of computer literacy so the student may be more efficient in a work environment employing computers. Students are expected to spend between 6 and 12 hours studying for the class during a week, 50 and 70 hours per 12-week term on homework using the computer, and 50 to 70 hours studying and doing assignments based on the lecture part of the course. Students with previous computer experience may omit this course if they pass a test administered by the faculty, thus students attending this class usually have minimal previous exposure and computer skills. Nonetheless, few students opt to omit the course.

A total of 347 students who had completed the EUC course in any one of ten consecutive university semesters (including summer sessions) were included in this study. Of this group, one-third were female, and slightly over 40% of the total population had previously taken the computer science course teaching traditional computer literacy. About 20% of the students worked full-time and studied part-time; 30% worked part-time while attending university full-time; and approximately 75% of the students were business administration majors.

Historical information concerning each student's cumulative grade-point

average (GPA) before attending the EUC class was obtained from the registrar's office. This source was also used to determine whether or not students had successfully completed (i.e., received a "D" or better) the computer science course and to evaluate their performance in this course (when applicable). In order to form equally sized groups according to academic ability, students were ranked from highest to lowest according to GPA, upon entering the course. The top 33.29% of the students, considered to be those of "high" academic ability, were placed into group A; the next 33.29%, the average ability students, were placed into group B, and the lowest 33.29% formed group C. GPA breaking points for the three groups were at 2.94, 2.48 and 1.92 (i.e., group C GPA 1.92 => 2.48 on a 4 point scale). One student failed the course[1]. Although using GPA as a grouping variable for academic ability is far from ideal, it is used extensively in research due to its simplicity and its ability to facilitate comparisons across studies (Butcher & Muth, 1985).

Definitions of Training Content, Methods and Criteria

The content of this course is designed to provide students with a knowledge and understanding of the principles of EUC using a PC, and of the larger systems of which they are more often a part, as suggested by Tornatzky (1986). The emphasis is on teaching generalized problem-solving and decision-making skills involving a computer that would be applicable to the wide range of work managers encounter. To accomplish this, the course uses both lectures and hands-on practice with computers. The objective of the lecture portion of the course is to give the participant some technical knowledge concerning makes of computers, flowcharting, system and software design and ergonomics, and also local area networks. Information system management concepts, and decision-making theory are taught to give the student the depth of knowledge needed to master various

work situations. Evaluation is accomplished through written tests.

The hands-on practice portion of the course first trains students to use the computer as a tool by teaching them the Disk Operating System (DOS), WordPerfect, Lotus, dBASE and Abtab statistical software, in this sequence. In order to use computers as a tutee (i.e., giving instructions with a computer programming language), students are also taught the programming language of BASIC. Evaluation of this section of the course uses learning measures, which take the form of office-work-styled information tasks involving problem-solving with the help of the PC. The lecture portion and the lab portion each count for 50% of the overall course grade.

As we are concerned with the effects of attending the introductory computer science course offered by the same university on the performance of students, a brief outline of the course follows. The objective of the course is to teach elementary computer programming, in an interactive computing environment, using BASIC. Programming, flowcharting, algorithms, the solution of elementary numeric and text-processing problems, and working with sequential files on a mainframe computer are also taught. All applications and practice are done on a mainframe computer terminal (dumb terminal), and a working knowledge of calculus and algebra is a prerequisite.

Aside from the obvious common factor of BASIC being taught in both courses, this introductory course also provides the individual with between 80 and 140 more hours of computer experience and exposure than computer classmates --a certain transfer of knowledge should occur (cf. Thorndike, 1913). This additional exposure should, furthermore, increase one's familiarity with the technology and, thereby reduce possible apprehension. Most importantly, students who have previously attended a computer science course voluntarily can be assumed

to be more interested in computers than their peers. An examination of the benefits gained from the computer science course will likely affect the considerations of future EUC course designs, which will want to balance the value of what is learned in the computer science course against the value of practice time in the EUC computer course.

Statistics

All of the computational analyses were performed on computers using the SYSTAT statistical package. Multiple regression was used so that not only could the significance of factors be determined, but also so that the magnitude of effect on the dependent variable in conjunction with the other variables could be inferred (Kmenta, 1971, pp. 374-376). The models for the overall course grade, lecture, computer lab, assignment and test grades were put in the form of linear regression equations to estimate the significance of the variable, and to facilitate an approximation of the relative weighting received by each independent variable. For correct application, multiple regression assumes that the residuals are normally (bivariate and multivariate normal) distributed. To test this assumption, the data used in each of the regression runs was tested for data outliers by looking at standardized residuals first, and then evaluating a histogram of the standardized residual plots. The analysis of these two procedures, and also the normal probability plots of the standardized residuals obtained, showed that the data collected met the normal distribution assumption.

Due to space limitations, the results for the regressions will not be presented in full here; however, in some cases a short summary will be given. The coefficients obtained via these regressions and the observed mean values (e.g., time spent practising with the computer, GPA and overall course grade) were used to calculate the <u>hypothetical number of hours needed practising one's</u>

skills with the computer to close the performance gap between the different student groups. These results will be discussed in detail in the sections below.

To examine whether grouping of the students based on their previous GPA and gender mattered, we also performed regressions for each group separately and a Chen[2] test. The results suggest that the grouping of students based on previous GPA as well as gender leads to significantly different regression coefficients in all of the studies, $p<05$. The possible effect of the semester during which the course was taken was also used to predict the dependent variable. Analyzing the residualized scores showed that term effects were minimal. These results can be obtained from the author.

To assess how much additional time practising computer skills was needed for the lower ability individual to equal the performance of a higher ability group, the observed values and the regression coefficients obtained for time were used. The difference in grade/points obtained was then divided by the time coefficient from the regression to obtain the additional time required to equal performance levels (see Kmenta, 1971).

Sample size. The four studies discussed in this paper will each use a different **sub-sample** of the total population (347 students). In some cases the sub-sample was relatively small (e.g., female low ability students). It is well known that the central limit theorem suggests that the sample size should be large enough to conduct a fair test. However, in practice researchers are constrained to use small samples as was the case here. The literature suggests that if the small sample has the same asymptotic unbiased properties that large samples have, there is no problem when using small samples in testing hypotheses. Furthermore, if the sample drawn is assumed to have a normal distribution, *t*-values will not be upward or downward biased (Harnett & Murphy, 1980, pp. 250-

257; Leamer, 1978, pp. 88-9, 104-5). The sub-samples drawn in this study meet these assumptions.

STUDY 1

The first study asked two questions: (1) Does previous academic performance affect the acquisition of non-technical computer literacy required for efficient EUC in an office setting? (2) Does the prior acquisition of more technical computer literacy facilitate the acquisition of non-technical computer literacy? To evaluate these questions, several equations were tested using multiple regression.

1 OVERALL COURSE GRADE $= \alpha + \beta_1 GPA + \epsilon$

2 OVERALL COURSE GRADE $= \alpha\alpha + \beta_1 GPA + \beta_2 CRBASIC + \epsilon$

3 OVERALL COURSE GRADE $= \alpha + \beta_1 GPAA + \beta_2 GPAB + \beta_3 GPAC$
$+ \beta_4 ACRBASIC + \beta_5 BCRBASIC + \beta_6 CCRABSIC + \epsilon$

4 LECTURE PORTION OF THE COURSE $= \alpha + \beta_1 GPA + \epsilon$

5 LECTURE PORTION OF THE COURSE α $= \alpha + \beta_1 GPA + \beta_2 CRBASIC + \epsilon\epsilon$

6 LECTURE PORTION OF THE COURSE $= \alpha + \beta_1 GPAA + \beta_2 GPAB + \beta_3 GPAC$
$+ \beta_4 ACRBASIC + \beta_5 BCRBASIC + \beta_6 CCRABSIC + \epsilon$

7 LAB PORTION OF THE COURSE $= \alpha + \beta_1 GPA + \epsilon$

8 LAB PORTION OF THE COURSE $= \alpha + \beta_1 GPA + \beta_2 CRBASIC + \epsilon\epsilon$

9 LAB PORTION OF THE COURSE $= \alpha + \beta_1 GPAA + \beta_2 GPAB + \beta_3 GPAC$
$+ \beta_4 ACRBASIC + \beta_5 BCRBASIC + \beta_6 CCRABSIC + \epsilon$

The above equations first established whether previous GPA (grade-point-average) would affect performance in the course (equations 1, 4 and 7). Secondly, the effect of previously acquired traditional computer literacy (CRBASIC) on performance was tested with equations 2, 5 and 8. Thirdly, we tested to see if the effects of GPA and CRBASIC were different for the three performance groups (A, B and C, e.g., GPAB and BCRBASIC), using dummy variables (equations 3, 6 and 9) coded 1 if the student was in the group, and 0 otherwise.

Results

Cumulative grade-point average (GPA). Table 1 indicates that the past GPA of the students studied was significant in helping to explain their overall grades in the EUC course. Moreover the data show that GPA also affects the student's performance in both the lecture portion of the course and the lab portion. Thus, the data confirm a positive answer to the first question.

Insert Table 1 about here

Previous computer course. Equations 2, 5 and 8 tested if previously attending a computer science course (CRBASIC) would significantly affect the performance in the EUC course (cf. Table 1). Data suggest that transfer of knowledge from the computer science course to the EUC course was apparent for the overall course grade and the lab portion of the course (procedural knowledge about computers). Interestingly enough, having previously attended a computer science course did not significantly relate to one's performance in the lecture portion of the course (declarative knowledge about computers). Hence, question two can be answered with a cautious "yes" as previous attendance of a computer science course primarily affects the acquisition of procedural knowledge (lab portion of course), thereby suggesting some transfer of knowledge.

Ability grouping. The data in Table 2 indicate that past GPA was of the greatest magnitude in influencing the overall course grade for above average ability students. A similar trend is apparent for both the lecture and the lab portions of the course. Transfer of knowledge from a previous computer science course to the EUC course was most apparent for average and below average achievers, especially when looking at the lab portion of the course (procedural knowledge), while for the lecture portion (declarative knowledge) the effect of

a previous computer science course upon performance was not significant. Performance increases for high achievers were not significant.

Insert Table 2 about here

Discussion

This study wanted to establish whether GPA, previously attending a computer science course, or ability level would make a difference in acquiring EUC skills. Having established that cumulative GPA did in fact significantly affect performance in the EUC course, it follows that previous attendance of a computer science course helps in explaining **beyond** what was already accounted for by GPA, especially performance in the lab.

As outlined earlier, however, previous GPA and having attended a computer science course may benefit various ability groups differently. Hence, we also tested for this factor and found that it was principally average and lower ability students who were able to transfer their knowledge from a previous computer science course into higher learning in the lab section which teaches mostly procedural knowledge about computers.

How do the results reported here compare to earlier research? That cumulative GPA affects learning of computer skills has been previously reported using computer science majors (e.g., Butcher & Muth, 1985). Furthermore, others have suggested that acquiring computer science knowledge may facilitate EUC skills acquisition (e.g., Jones & Lavelli, 1986). Study 1 tested this assumption, and suggests that a certain transfer of knowledge is occurring between the knowledge acquired in the computer science course and the EUC course. Most importantly, the computer science course may help lower ability students to understand basic computer principles more easily. This, in turn, will reduce

the cognitive resources needed to learn new EUC skills, thereby building sequences of efficient associations between stimulus inputs and response operations faster than otherwise (Ackerman, 1988).

The results suggest that if we try to assess differences between students, we should **first** analyze ability groups separately by studying how GPA and previously attending a computer science course may, for instance, affect time requirements for skill acquisition (e.g., Adams, 1987; Shiffrin & Schneider, 1977). **Second**, the above should also be assessed between genders since the literature strongly suggests that difference in learning computer skills are apparent (e.g., Anderson, 1987; Lockheed, Nielsen & Stone, 1985).

STUDY 2

Since we are hypothesizing that the benefits gained from previous computer science course experience are mostly in the way of automatic processes, we must concern ourselves with whether or not actually practising EUC computer skills represents a more efficient use of the student's time than participation in such a course (in terms of improving the student's performance in the EUC course). It also remains to be determined whether differences in learning computer skills are gender related. For these reasons, this study asked the following questions: (1) Do women and men with similar academic abilities perform equally well in the EUC course? (2) How much additional practice time on the computer do members of the lower performing sex need to equal the performance of the higher performing sex (especially for average and lower achieving students); and (3) how is this affected by the acquisition of traditional computer literacy?

Based on the results obtained in Study 1, **grouping participants based on** previous academic performance **(GPA)** was **justified**. To examine whether grouping of the students based on their gender mattered, we also performed regressions

for each group (M = Male, F = Female) separately, as well as combined, and performed a Chen[3] test. The results suggest that the grouping of students based on gender leads to significantly different regression coefficients, $p<01$.

Again dummy variables were used to establish the effects of one's GPA (GPAAM = highest male performers), previously acquired computer literacy for each gender (ACRBASICM = male and ACRBASICF = female), and hours spent practising one's skills using the computer (AHRSM and AHRSF). In addition to the regression equation for the overall course grade (equation 10), the same set of independent variables was used to predict the student's grade in both the lecture portion (equation 11) of the course and the lab portion (equation 12). Hence, three equations were used for the highest performing group (GPAA and ACRBASIC), another three for the average performers (B), and a further three for the below average ones (C). Equation 10 has been added below for illustrative purposes.

$$\text{OVERALL COURSE GRADE}^{4} = \alpha + \beta_1\text{GPAAM} + \beta_2\text{GPAAF} + \beta_3\text{ACRBASICM} + \beta_4\text{ACRBASICF} + \beta_5\text{AHRSM} + \beta_6\text{AHRSF} + \epsilon \tag{10}$$

Results

Above average academic ability. Table 3 shows the results obtained when testing the regression equations for each ability group separately. For both women and men the results in Table 3 show that having previously attended a computer science course does not significantly affect subsequent performance in a course teaching computer literacy for the office setting. Interestingly enough, this group of students (both male and females) are also unable to increase their performance either in the lecture or the lab portion of the course by spending more time practising their skills (HRS). The results support Study 1, which also showed that high ability students did not benefit from

previously attending a computer science course, with the distinction that Table 3 reveals this to be true for both genders while the previous study limited itself to the ability group effects.

Average academic ability. The results in Table 3 suggest that previously attending a computer science course helps average ability students in the lab (acquiring procedural knowledge). Males also benefit from this additional computer experience in the lecture portion (declarative knowledge) of the course. Both genders benefit in their overall performance, in the class teaching computer literacy for office settings, from a computer science course. Neither gender was able to significantly transfer effort spent on practice (hours) into higher performance.

Insert Table 3 about here

Below average academic ability. The results in Table 3 suggest that men are able to benefit significantly from previous experience obtained in a computer science course, in the lab section. However, only women are able to improve their overall performance by having previously attended a computer science course. The overall effects of computer science course experience on learning for the lower achieving male group were not significant; computer science course experience did, however, give lower achieving females an average .65 grade point increase, compared to a mere .23 grade points increase for males[5]. Both genders benefit from additional time spent using the computer to practice their newly acquired skills, however only men are able to transfer such efforts into higher overall performance.

Time effects. To calculate the additional time needed by the lower performing group to close the performance gap, the regression coefficients

obtained in Table 3 were used. Hence, the results in Table 4 show the estimated additional time needed by the lower performing group to close the performance gap to the higher performing one. Based on the results obtained in Table 3 it is obvious that time effects (see regression coefficients in Table 3) are only significant for lower ability students in the lab portion, while females benefit from time efforts in the overall grade obtained for the course. Consequently, the following results are limited to lower ability students.

Results in Table 4 suggest that, for the overall course grade males have to invest an additional six hours to equate their performance with females if both have previously attended a computer science course. Without such experience females must invest an additional 21 hours. For the lab section in both cases (with or without computer science course) females must invest some additional time. The time differences are minimal and neither gender group is better off by having previously attended a computer science course. Most important, however, is the fact that the additional time efforts reported are not statistically significant. Since the time coefficients were not significant (cf. Table 3) for the lecture part of the course, the estimated time needed to equal performance to the higher group of the same sex was not calculated.

Insert Table 4 about here

Discussion

The results suggest that time effort exerted by high ability students is not significantly influencing learning performance. One reason may be the fact that course content is adjusted to their lower performing peers, thereby limiting the potential learning differences which might occur based on cognitive ability (Ackerman, 1987). Nonetheless, separation based on ability should be

avoided since differences based on ability are otherwise reinforced, thereby increasing the computer skills gap between ability groups (Sorensen & Hallinan, 1986).

The data also show that females appear to be more able in transferring previously acquired computer knowledge into higher performance. Most important is that, for the lab portion of the course, lower ability students of both genders benefit from time efforts. Once again, time spent practising facilitates the automation of some processes, thereby allowing lower ability students to acquire the speed and accuracy needed for better learning performance (cf. Schneider & Shiffrin, 1977).

The results in this study also cast some doubts upon the findings of previous research, which reported that women do not perform as well as men in computer courses (e.g., Campbell & McCabe, 1984; Lockheed, Nielsen & Stone, 1985). Reasons for previously cited gender differences may include an acceptance of stereotypes which lower womens' expectancy of doing well in a computer course. However, successfully completing a prior computer course raises performance expectancy for subsequent courses, often leading to better performance (cf. Eden & Ravid, 1982). The data obtained here would further suggest that the transfer of knowledge from the computer science to the EUC course is statistically significant, but not too great in magnitude, for either sex. A further clarification is needed, however, to determine whether more practice using the computer in the EUC course is a more time efficient alternative for low ability women and men to achieve the same performance level as the higher ability group. The following study will address this issue in some more detail.

STUDY 3

Higher ability students (as studies 1 and 2 indicate) seem to have little problem acquiring computer literacy no matter what the format of the course. This suggests that the focus of further research should be upon assessing the effects of gender, practice time and previous computer science course experience specifically for the performance of students with lesser ability. Certain training methods have been shown to be less beneficial to lower ability individuals than others (Gettinger, 1985; Lepper, 1985; Biggs & Kirby, 1984), so it is hoped that the results of this next study will give a better idea of the type of training methods that will help these individuals. This study concentrates specifically on differences within a gender group, as these may affect learning and training strategies used to acquire computer skills.

This study asked the following questions: (1) Does previous computer exposure help lower achieving students in the EUC course equal the performance of average achievers? (2) How many additional estimated hours of practice are needed by lower academic achievers to equal the performance of average academic achievers of the same sex when a) neither group has computer science experience, b) only the lower achievers have this experience, and c) only the average achievers have this experience[6]? (3) Are these results similar for both males and females?

19 OVERALL COURSE GRADE[7] $= \alpha + \beta_1 GPABM + \beta_2 GPACM + \beta_3 BCRBASICM + \beta_4 CCRBASICM + \beta_5 HRSBM + \beta_6 HRSCM + \epsilon$

The equations help to test the effect of academic ability (GPA), previous attendance in a traditional computer course (CRBASIC) and hours spent practising computer skills for average academic ability male students (HRSBM = Male) and for less than average ability males (C). Again, the same independent variables were used to predict the grade obtained in the lecture portion and the computer

lab of this course. Thus, three regression equations were used for male students and three separate ones for female students. Moreover, the regression coefficients obtained for hours spent practising (HRS) were used to calculate the potential additional time needed by the lower academic ability group (C) to close the performance gap to their average academic ability peers (B). Due to space limitations the six regression runs will not be presented here, instead, a brief discussion of the results will be given.

Results

Female. The only significant effect discovered, when looking for the influence of previous computer exposure on female student performance in the EUC course, was for average achievers in the overall course grade, which improved after having acquired such exposure. Nearly significant effects ($p<.06$) were recorded for the effect of previous computer exposure upon the lab section of the course. Previously attending a computer course did not benefit lower ability females in any portion of the course teaching computer literacy for the office setting.

Time effort spent on practising skills using the computer benefits lower ability females overall, but the effect is greatest in the lab portion of the course. The data clearly suggest that female lower ability students spend their time more efficiently by putting more hours into practising new acquired skills, rather than attending a computer science course.

Male. The results obtained indicated that average achieving males benefitted significantly in all ways from having previously attended a computer science course. This experience improved performance in both the lab and the lecture portions of the course, as well as increasing the average overall course grade. Lower achievers, in contrast, seemed to benefit from such additional

exposure only in the lab portion of the EUC course, although previously attending a computer science course teaching traditional literacy reduced the performance gap between this group of males and their average achieving peers considerably.

Time effects. When calculating the estimated additional time needed to close the performance gap to the higher performing group of the same sex, these numbers were not calculated for the lecture portion of the course, since the coefficients for time obtained in the multiple regression were not significant.

Insert Table 5 about here

Column three shows the differences between groups most succinctly. For instance, while estimated additional time efforts are insignificant for women, they are significant for men. To improve one's overall course grade without having previously attended a computer science course requires a male average ability student to invest an estimated additional 22 hours practising his skills on the computer to equal performance with the lower ability peer who previously attended the computer science course. For the lab portion of the course the estimated hours required rise to 54.

Columns one and two show that estimated additional hours required by lower achievers without a computer science course increase slightly for males if the average achiever has previously attended a computer science course. For females the estimated time requirements stay the same (22 hours), or are reduced (from 17 to 13 hours) in the lab portion of the course.

Discussion

Probably the most important result presented in this study is the fact that lower ability students of either sex are not able to transfer knowledge

previously acquired in a computer science course into higher overall performance in this course. Nevertheless, practice time with the computer helps lower ability students in the lab portion of the course.

Looking at individual differences in skill learning seems to give further credence to our earlier hypothesis that automatic processes are used extensively by lower ability individuals of both sexes to equal the performance of their average peers in the lab section of the course, and that the development of such processes is somewhat facilitated by previous formal computer exposure. The data also indicate that controlled processes, manifested in the lecture portion of the course where the development of automatic processing components is limited, are one possible reason it takes longer (more practice time) for lower ability students of both sexes in this portion of the course to achieve average performance (Fleishman & Quaintance, 1984).

Another factor which possibly explains the above differences is fact that practising one's skill by using the computer does not help improve level of performance when it comes to declarative knowledge being tested with a paper-and-pencil test (see lecture portion of the course). In such an instance, the individual may be best advised to "hit the books" instead of practising procedural knowledge by using the computer.

This study established that lower ability students benefit from time efforts in the lab portion of the course. The issue remaining is how previous experience obtained in a computer science course and time spent practising one's skills in this course may affect performance when doing job-like assignments as homework versus doing the task under time constraints as in an examination.

STUDY 4

The fourth and final study examines the effect of time constraints upon performance. Automatic processes are especially important to performance under time pressure as they help save time. For instance, knowing how to work with a software program and the keyboard function keys without consulting the manual saves valuable time which can be used for the controlled processes requiring thought and involving complex decisions (e.g., how to formulate a sentence or solve an accounting problem with the help of a spreadsheet). In contrast, when doing an assignment on one's own time (e.g., homework), the manual can be used and automated processes are far less important as any time constraints are self-imposed. Nonetheless, time spent practising skills may help in developing a more insightful and innovative solution, making more extensive use of one's declarative knowledge about the subject (e.g., accounting assignment), and transferring such efforts into using the computer more effectively than otherwise possible.

Study 4 asked the following questions: (1) How is the performance of average and lower achievers in the EUC course affected by previous computer science course experience a) when writing examinations on the computer under time pressure, and b) when doing work-like assignments without externally imposed time constraints? (2) How much estimated additional time is required for lower achievers of either sex to equal the performance of average achievers of the same sex in doing assignments and in working with the computer under time pressure?

$$\text{25} \qquad \text{WORK-TYPE ASSIGNMENTS}^{8} = \alpha + \beta_1\text{GPABM} + \beta_2\text{GPACM} + \beta_3\text{BCRBASICM} + \beta_4\text{CCRBASICM} + \beta_5\text{HRSBM} + \beta_6\text{HRSCM} + \epsilon$$

The same independent variables were used to predict the work-type assignments of the course as in Study 3, but predicting the lab portion only.

Again, a different regression equation was used for females. Two additional regressions for both females and males were run separately to predict performance without time pressure (e.g., doing assignments on one's own time using the computer), and with time pressure (e.g., exams using the computer to do tasks). The HRS (time) coefficients obtained in these regression runs were then used to calculate the estimated additional hours needed for the less than average performers (C) of each sex to close the gap to their average performing peers (B). Due to space limitations the two regression runs will not be presented here, instead, a brief discussion of the results will be given.

Results

Performing under time pressure. The regression results indicate that both lower and average achieving males benefitted from a previous course teaching traditional computer literacy when writing exams using the computer. However, only the lower achieving group would gain a significant improvement in this area as a result of additional computer skills practice.

For females the results were different; only average achievers benefitted from a previous traditional computer literacy course when performing on a computer under time pressure. While lower ability females are able to transfer additional time spent practising skills into higher performance when doing a computer-based task under time constraints, average ability females fail to do so.

Performing without time pressure. While previous computer exposure did not significantly affect the performance of either males or females when doing assignments, additional practice time did improve learning performance, under time pressure, for average and lower achieving students of both sexes.

Additional time effort needed to equal performance levels. Table 6

suggests that the estimated additional time effort required by female lower achievers without a traditional computer literacy background to equal the performance of female average achievers is minimal. Additionally, the performance of female students of either group (average and lower achievers without previous computer exposure) would be improved more by spending about two additional hours per week using the computer than by having previously attended a computer science course. Even under time pressure, the potential additional time effort required for lower achievers without traditional computer literacy to equal the performance level of average achievers with have the computer science course is limited. (cf. Table 6)

Insert Table 6 about here

Table 7 shows the data obtained for men. The most substantial difference from the results reported for females is that, under time pressure, average achieving males without a previous computer science course have to spend an estimated additional 691 hours to equal the performance of lower achieving males with computer science course experience (this large difference is based on small time coefficient obtained for males in the regression equation). This suggests that some process may be occurring of which we were not aware but, nonetheless, may have little to do with practice time (e.g., lower ability students gained substantial self-confidence by attending the computer science course previously, thereby performing well under time pressure in this course which was not the case for average ability students who had not previously attended a computer science course). Other results indicated that only limited additional time was needed to match the performance of the higher ability group.

Insert Table 7 about here

Discussion

The major finding of this study was that lower achievers of both sexes would need additional time to practice on computers to equal the performance of their average achieving peers of the same sex when working under time pressure, with males needing more time than females. The assignment section shows that lower achieving men would need less additional practice time than women to equal the performance of their average achiever peers of the same sex.

The data obtained in this study once again demonstrates that extensive practice is needed by lower achievers, especially if they wish to develop the automatic processes which will allow them to perform similarly to average achievers. We say "perform similarly" not "perform equally" as, while the individual with well developed automatic processes may be able to match the speed with which the higher achieving individual performs a task, he or she may not be able to approach the problem as creatively. Task-specific variance among individuals with similarly developed automatic processes will therefore ultimately depend upon the individual's innate cognitive ability, since the controlled processes necessary to do novel tasks cannot be internalized, as we have seen. Though this variance may be reduced somewhat by spending a great deal of time doing novel assignments and so forth, the performance of individuals with similar skills under time constraints will differ according to their ability to think quickly (Ackerman, 1987; Fleishman & Quaintance, 1984).

This study also indicates that the way students are taught procedural knowledge (how to do tasks when using a computer) is quite efficient, since learning differences based on ability are limited for computer tasks such as homework or performing under time constraints (exams). Hence, lower ability

students of either sex can be assumed to have reached phase three of automatic processing, performing the computer-mediated task with little cognitive attention (Gattiker, 1989).

CONCLUSION

As we have seen, a number of factors affect ability to acquire computer literacy. Familiarity with traditional computer science seems to be of less value to the individual wishing to develop the business skills needed for employment, than increased practice of newly acquired EUC skills. Performance in written exams used in the lecture part of the course hints that lower achievers may be affected by the cognitive resources which they can devote to the task. This may leave some performance gaps open which are impossible to close (Ackerman, 1987).

However, the above gaps due to differences in the amount of cognitive resources available to different ability groups should be kept as small as possible. As this study clearly indicates, academically lower achieving individuals need substantially more time to reach the same level of computer performance as their higher achieving peers. However, most important is the fact that additional practice time can help to reduce the performance gap. This result confirms earlier research in mathematics (e.g., Keith, 1982) and other subjects (e.g., Snow, 1986; Stanley, 1980) which reported that additional training time (around two hours per week) helps lower ability students to close the performance gap to their higher ability peers. Thus, this study would suggest that the same is true for EUC training.

One might raise the issue that using a student sample in this study instead of employees limits generalizibility. The trend does indicate, however,

that formal computer training is being moved increasingly from organizations to post-secondary institutions (e.g., Leontief & Duchin, 1986, chap. 4). Moreover, firms are cutting down on computer training efforts for various reasons, and sending their workers to educational institutions for various reasons (Cooper McGovern, 1988). Hence, universities, and especially their business schools, must offer training programs in response to this increased demand. It is more important, however, that business schools must design efficient training programs to ensure that their graduates have the necessary computer skills when entering the workforce (Jones & Lavelli, 1986). This series of studies is, therefore, a response to the need for more research in the area of computer training for management students and employees.

Implications for Information Centre Managers and Educators

The most important implications for managers and educators and their end-user training programs could be stated as follows:

(1) Traditional computer literacy is only of limited use in relevant task situations involving EUC. Thus, training end-users in this area may not warrant the time needed to learn such skills and might be ignored for most end-users in office settings (Studies 1 - 4).

(2) Participants of training seminars should be grouped based on end-user needs. While some training may be the same for all groups (e.g., learning about DOS, networking and word processing), specific applications may differ. Moreover, software applications may differ from industry to industry. Hence, for the latter part of training end-users may be grouped based on type of function and, if possible, industry.

(3) Since average achievers benefit most from learning settings that provide hands-on experience and which simulate future applications of newly

learned tools in real-life situations, training programs (i.e., seminars attended during normal working hours) that provide such settings are recommended (Studies 1 & 2). Thus, training should enable end-users to apply newly mastered theory and concepts by solving tasks which simulate realistic job situations using the computer.

(4) Since novel and inconsistent task processing does not allow for much automatic processing, additional tutoring for lower achievers may be necessary to ensure that they will acquire an average level of theoretical and technical knowledge. This tutoring could possibly come from more advanced students who are more at ease with the material (peer teaching).

(5) To ensure that the individual will put in the effort needed to increase performance, access to computers should be made easier. Organizations should allow employees to borrow computers for private use, or help finance employee purchases of computers. Universities should help students purchase computers by offering them low cost machines through special agreement with suppliers (Studies 1 - 4).

(6) To encourage employees to acquire the EUC skills needed to perform well on the job, a reward system should be designed. For one, companies should support employees acquiring EUC skills at post-secondary institutions by paying for tuition, materials and fees. Moreover, the in-class time should be paid as an incentive for employees who will have to devote their leisure time to practice for at least twice as many hours as they spend in-class. Thus EUC training becomes a mutual effort. The employee must invest as well as the firm, but the latter still saves resources by not having the training in-house.

(7) To further encourage EUC training, the firm should make EUC skills part

of the regular performance appraisal and the employee's personal skills development plan. Thus, the employee is helped with assessing his or her skills and, after acquiring the EUC skills level necessary, can, and will, be rewarded thus further reinforcing continuous education activities.

The above suggestions are, of course, not all encompassing. Nevertheless, they address some of the most important problems faced by managers and educators today. Without addressing the above managers risk having a workforce without the necessary EUC skills to make efficient use of the technology available, thus reducing the firm's level of competitiveness. For educators, training programs must be designed to meet the requirements outlined above, the needs of today's workforce for EUC training. A challenging task which will require a lot of work and continuous assessment of its success.

Theoretical Implications

The series of studies discussed here has supplied important information in the domain of end-user training. Most important is that management training literature cannot continue ignoring the advances in other disciplines, such as cognitive psychology, education, educational sociology and office automation, when doing research and designing training programs for EUC skills. The data reveal that integrating previous research in these disciplines can help the advancement of EUC training research considerably.

The studies also show that there are numerous issues which could not be dealt with. Below is a list of some of the more pertinent issues which must be addressed by future research to improve the efficiency of computer training.

1) How do people absorb information and learn about computers? Do they process information randomly or sequentially? The answer to these questions may influence how future computer training materials will be

designed to best meet students' learning needs and preferences.

2) The instructor's <u>learning style</u> may further affect the environment for the student. Hence, if learning style between instructor and student differ, training efficiency and performance levels attained by participants of computer training may be hampered.

3) The amount of time the individual spends with the different types of software packages in a course may also affect overall performance in a variety of ways. For example, it is possible--we might even dare to say, likely--that males use computers for word processing more than females (e.g. papers, private correspondence and letters) as computer use may be the only way for males to avoid the negative stigma of typing (Morgall, 1983). However, this kind of use may put males at a disadvantage when doing tasks under time pressure which requires the use of other software packages.

4) That women are more efficient in learning to use the computer than men may, in part, be due to points 1-3 raised above. For instance, it is possible that women manage their practice time more effectively by not specifically concentrating on excelling in one area (e.g., for men this could be word processing), but try to achieve high performance levels everywhere. Another issue which must be addressed is the fact that women may be more motivated than men to excel simply because high EUC skill levels may assure better jobs (Jones & Lavelli, 1986) and reduce job segregation by offering employees the skills needed to succeed in the workplace.

5) Having an aptitude for mathematics may affect transfer of knowledge, and be helpful in achieving, more quickly, acceptable computer literacy. How

transfer of knowledge, and particularly from which subjects, may help computer training is hardly known or understood.

6) Another issue still to be addressed is self-expectancy and effort in computer training by the participant. Based on earlier research, a high self-expectancy and willingness to put substantial effort into learning computer skills will ultimately improve performance beyond expectations based on academic ability (cf. Eden & Ravid, 1982).

The above illustrates that future research efforts would do well to combine aspects of four traditions: education, psychology, sociology and information systems management. Without drawing on the richness of previous research and integrating it into future efforts, these issues may not be answered thoroughly and adequately. An attempt has been made here to expand the existing research on computer training by moving beyond one single discipline, and studying students in EUC training who are not especially interested in computers (e.g., computer science majors), and who come from different ability groups (high and also low level of academic ability).

Issues for the 1990's

The penetration of computers into all spheres of life will have significant effects upon their use in the workplace. Public policy makers, managers, unions and also employees must come to terms with numerous issues to avoid undesirable outcomes. The situation today may be similar to the one in the 1930's when cars began to have a major effect on society. At that time, nobody thought about their future effects upon leisure and work, urbanization or environmental outcomes (e.g., air pollution, using arable land to build an extensive road system, and safety of human life). Timely discussion of these issues might have led to some early policy changes for preventive purposes. For

computers, and especially computer training, the potential negative effects should be forecasted, researched and discussed to allow public policy decision makers to take the necessary steps to avoid them. The following represents an incomplete catalogue of some questions which must be addressed in the training domain to facilitate an effective, positive use of technology.

1) Computer literacy may be used as a barrier for labour market entry in some professions, jobs and industries. Thus, what type of training will be needed to assure the widest possible group of potentially employable people will have this skill?

2) Rapid technological developments will, however, make it extremely difficult to define computer literacy from an educational policy perspective. Literacy may change faster than policy can be implemented in the educational system. Thus, training provided prior to university may be outdated from its inception. This requires that educational policy in the computer domain be adjusted on a regular basis (e.g., every three to five years) to account for changes in hardware and software. Moreover, <u>teachers must become</u> not only well versed in mathematics, writing and reading, but must also be <u>computer literate</u>.

3) While youngsters may have the "right" skills upon leaving school, a few years later their skills may be outdated. Continuous training and retraining may, therefore, become one of the single most important issues determining a person's employability (cf. Gattiker, in press a). New programs must be implemented to ensure that the 40-70 year old population continuously upgrades its skills. The major challenge here will be providing the resources for such training. Since each party would have some vested interest, financing should come from the government (tax

incentives to firms and employees), the firm and also the employee (see Levin and Schuetze (1983) for an extensive discussion of possibilities).

4) Technology adoption may lead to up-skilling or de-skilling of certain jobs (Gattiker, in press b). Two types of training are likely to occur for the two types of computer application: (1) routine and general office work, which requires mostly automated processes, and (2) specialized EUC applications, where task performance also requires extensive controlled processes. Thus, two classes of EUC jobs may emerge, with the "privileged" employees holding interesting jobs and experiencing a high quality of work life and good remuneration (salary and fringe benefits), while the "not-so privileged" lack these advantages. Some research would suggest that technology adoption can lead to either outcome depending upon the situation (e.g., Attewell, 1987; Shaiken, Herzenberg & Kuhn, 1986).

5) If the not-so privileged positions for computer-mediated work increase as a percentage of the total jobs available, conflict may arise with today's educational development. The inherent conflict stems from the fact that today's average employee may have enjoyed more formal education than ever before. Education may, however, increase the desire for interesting and challenging computer-based jobs (cf. Spenner, 1983, Kohn, Schooler, Miller, Miller, Schoenbach, & Schoenberg, 1983). Hence, quality of work life could decrease for some. Such an outcome is undesirable and may lead to social problems. How could policy help in preventing these negative outcomes, and what can educational institutions do to help for the benefit of all employers and employees?

If technology is to be used to improve the quality of work life the above catalogue of questions must be addressed and resolved. These questions

represent a challenge for public policy makers, employers, unions, employees and researchers. We are at the early stages of discussing methods of computer training which are efficient, equitable, flexible and comprehensive. Now is the time for decision makers in public-policy, management, unions, researchers, and employees themselves to start addressing the above issues. The results will have a significant effect upon future training strategies in the EUC domain. As we pursue these questions and areas of research further, we can expect that new theory will be proposed and that revisions to training methods will become the norm.

FOOTNOTES

1) The grade distribution of the sample used for grouping the students represents the general grade distribution of the university for third year courses.

2) The 'Chen' test is the most popular way of testing whether or not the parameter values associated with the data set (e.g., no dummy variable for gender = restricted model) are the same as those associated with the data set using an unrestricted model (i.e., dummy variable, in this case for female and male students each) (Kennedy, 1985, pp. 87-8).

3) The 'Chen' test is the most popular way of testing whether or not the parameter values associated with the data set (e.g., no dummy variable for gender = restricted model) are the same as those associated with the data set using an unrestricted model (i.e., run a regression for each gender) (Kennedy, 1985, pp. 87-8).

4) The possible effect of the semester that the course was taken was also used to predict the dependent variable. Since these effects were not significant, they are omitted here.

5) The university uses a four-point system (4 points = A; 3 points = B), thus females may improve their grade from a B to a A by having previously attended a computer science course (rounding up effect for .65 grade point improvement).

6) Since the major focus was on determining the least **estimated** amount of additional practice time needed for the lower achieving students (including time spent for computer science course), comparisons between average and lower achievers with both groups having computer science course experience were not of major interest. Testing of this <u>was</u> done, however, and the data suggested that lower achievers can somewhat limit the additional time needed to close the performance gap to their average peers, if both groups have previously attended a computer science

course.

7) Once again, the possible effect of the semester that the course was taken was used to predict the dependent variable using dummy coding. Since these effects were not significant, they are omitted here.

8) The possible effect of the semester that the course was taken was again used to predict the dependent variable with a dummy variable. Since these effects were not significant, they are omitted here.

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Table 1

Regression Results for Student Performance: GPA and BASIC Course Grade

Equation	Dependent Variable	Independent Variables[1] Constant	GPA	CRBASIC	d.f.	Adj. R^2
[1]	Overall Course Grade[3]	-0.347	1.202		126	0.419
		(-1.01)	(9.63)*			
[2]	Overall Course Grade	-0.553	1.192	0.453	125	0.486
		(-1.70)	(10.21)*	(4.17)*		
[4]	Lecture Portion of the Course[4]	36.726	12.738		126	0.307
		(7.95)*	(7.57)*			
[5]	Lecture Portion of the Course	35.484	12.716	2.728	125	0.319
		(7.66)*	(7.62)*	(1.77)		
[7]	Lab Portion of the Course[5]	42.459	13.763		126	0.309
		(8.55)*	(7.60)*			
[8]	Lab Portion of the Course	39.963	13.720	5.486	125	0.363
		(8.28)*	(7.89)*	(3.42)*		

[1] *t* ratios are in parentheses beneath estimated coefficient $^*p < 0.05$

[3] This is the overall grade the individual received in this course (A=4, B=3, C=2, D=1, F=0). 50% is made of the person's Lecture portion grade and 50% is made of the person's Lab portion grade.

[4] The lecture portion of the course was made of two exams. One assessed the student's general expertise regarding PC functions, the other tested his or her knowledge about computers use in the business world.

[5] This section is composed of ten homework assignments (20%) of lab portion of course) two practical exams (20% each of Lab mark total), and two multiple choice exams (also each 20% of Lab mark total).

Table 2

Regression Results for Student Performance: Different GPA and BASIC Course Ability (Grade) Populations

Dependent Variable		Constant	GPAA	GPAB	GPAC	ACRBASIC	BCRBASIC	CCRBASIC	d.f.	Adj. R^2 [2]
		Independent Variables[1]								
[3] Overall Course Grade[3]	=	-0.329	1.181	1.125	1.109	-0.154	0.525	0.445		
		(-0.74)	(7.68)*	(7.26)*	(5.54)*	(-0.36)	(3.58)*	(2.51)*	121	0.496
[6] Lecture Portion of the Course[4]	=	39.816	11.445	11.092	11.398	0.557	3.704	1.303		
		(6.11)*	(5.06)*	(4.86)*	(3.87)*	(0.09)	(1.72)	(0.50)	121	0.282
[9] Lab Portion of the Course[5]	=	39.275	14.381	14.262	13.545	-2.229	4.611	7.949		
		(6.06)*	(6.39)*	(6.28)*	(4.62)*	(-0.36)	(2.1?)*	(3.05)*	121	0.388

[1] *t* ratios are in parentheses beneath estimated coefficient $*p < 0.05$

[3] This is the overall grade the individual received in this course (A=4, B=3, C=2, D=1, F=0). 50% is made of the person's LAB portion grade and 50% is made of the person's CLASS portion grade.

[4] The lecture portion of the course was made of two exams. One assessed the student's general expertise regarding PC functions, the other tested his or her knowledge about PCs use in the business world.

[5] This section is composed of ten homework assignments (20%) of LAB portion of course) two practical exams (20% each of LAB mark total), and two multiple choice exams (also each 20% of LAB mark total).

Table 3

Regression Results for Student Performance: Different GPA, Basic Course Ability (Grade) Populations According to Gender

DEPENDENT INDEPENDENT VARIABLES[1]

HIACAD

Equation	Dependent Variable	CONSTANT	GPA3M[6]	GPA3F[6]	CRBASIC3M	CRBASIC3F	HRS3M	HRS3F	d.f.	Adj.R^2
[10]	Overall Course Grade[3]	.524 (0.57)	.867 (3.28)*	.932 (3.26)*	.027 (-0.13)	.299 (1.46)	.002 (0.51)	-.002 (-0.34)	70	0.166
[11]	Lecture Portion of the Course[4]	55.543 (6.02)*	8.130 (3.05)*	8.720 (3.03)*	-.283 (-0.14)	1.780 (0.87)	.033 (0.86)	.006 (0.14)	70	0.429
[12]	Lab Portion of the Course[5]	46.409 (3.77)*	10.336 (2.91)*	13.124 (3.42)*	2.698 (0.99)	2.061 (0.75)	.054 (1.04)	-.043 (-0.71)	70	0.131

MEDACAD

Equation	Dependent Variable	CONSTANT	GPA3M	GPA3F	CRBASIC3M[7]	CRBASIC3F[7]	HRS3M	HRS3F	d.f.	Adj.R^2
[13]	Overall Course Grade	1.600 (0.93)	.354 (0.56)	.305 (0.48)	.526 (3.09)*	1.184 (3.29)*	.001 (0.20)	-.001 (-0.14)	70	0.204
[14]	Lecture Portion of the Course	50.527 (2.74)*	10.423 (1.54)	9.893 (1.46)	4.701 (2.57)*	7.708 (1.99)	-.036 (-1.00)	-.046 (-0.61)	70	0.348
[15]	Lab Portion of the Course	86.501 (4.26)*	-4.007 (-0.54)	-3.325 (-0.44)	5.110 (2.53)*	8.630 (2.02)*	.018 (0.46)	-.032 (-0.39)	70	0.190

LOWACAD

Equation	Dependent Variable	CONSTANT	GPA3M[4]	GPA3F[4]	CRBASIC3M	CRBASIC3F	HRS3M[8]	HRS3F[8]	d.f.	Adj.R^2
[16]	Overall Course Grade	-2.429 (-2.15)*	1.534 (2.93)*	1.282 (2.37)*	.239 (1.46)	.669 (2.00)*	.014 (2.90)*	.016 (1.76)	70	0.355
[17]	Lecture Portion of the Course	31.518 (2.13)*	15.657 (2.28)*	13.499 (1.90)	-.510 (-0.24)	7.455 (1.70)	.050 (0.80)	.049 (0.41)	70	0.138
[18]	Lab Portion of the Course	12.616 (0.95)	12.695 (2.07)*	8.638 (1.36)	6.847 (3.59)*	6.316 (1.61)	.351 (6.30)*	.431 (4.09)*	70	0.600

Note. The equations have been arranged in their appropriate groups (1, 2 or 3). For each academic achievement group the effect of GPA, having acquired traditional computer literacy (CRBASIC), and time spent on homework using the micro-computer (HRS) have all been appropriately subdivided by gender (M or F). Additionally, the possible effect of the semester that the course was taken (TERM) was used to predict the dependent variable; the effects were, however, not of significant magnitude to warrant their inclusion in this table.

1 *t* ratios are in parentheses beneath estimated coefficient *$p < 0.05$

3 This is the overall grade the individual received in this course (A=4, B=3, C=2, D=1, F=0). 50% is made of the person's LAB portion grade and 50% is made of the person's CLASS portion grade.

4 The lecture portion of the course was made of two exams. One assessed the student's general expertise regarding PC functions, the other tested his or her knowledge about PCs use in the business world.

5 This section is composed of ten homework assignments (20%) of l ` portion of course) two practical exams (20% each of LAB mark total), and two multiple choice exams (also each 20% of LAB mark total).

6 GPA of highest performing group according to gender.

7 CRBASIC for average performing group according to gender.

8 HRS spent on practising one's skills using the computer by the lowest performing group according to gender.

Table 4

Estimated Additional Hours Required by the Lower Performing Sex in the Lower Ability Group to Equal Performance to the other Sex[1]

Previous Computer Course Attended (CRBASIC)	Lower Academic Ability No	Lower Academic Ability Yes
Overall Course Grade	21 hours for females	6 hours for males
Lab Portion of the Course	7 hours for females	8 hours for females

N= 17 females, 65 males

1 Using estimated regression coefficients for time (see Table 3).

* *p*<.05. Using a two tailed *t*-test to determine whether or not additional time required by a given student's gender group would place the student outside the 95% confidence interval for the original observed time spent on the computers (by that gender group). For instance, the mean value of time spent in the computer lab portion of the course for lower achieving female students was 68.453 hours with a standard deviation of 18.567. Thus, an additional 7 hours would be required for these students to equate themselves with their lower achieving male peers in the computer lab portion of this course (assuming that neither group has received credit for the computer science course). This would imply a total time commitment of 75.5 hours (68.453 + 7) for these lower achieving female students, which remains within a 95% confidence interval of the originally observed mean (68.453). Consequently no real adjustment in student behaviour is required to equate the two genders within this group of academic achievement.

Table 5

Additional Hands-On Practice Hours Required by **Lower Achievers** to Equal the Performance of Same Sex Average Achievers[1]

	Lower Ability	= Average Ability	Lower Ability	= Average Ability	Lower Ability	= Average Ability
Previous Computer Course (CRBASIC)	NO	NO	NO	YES	YES	NO
DEPENDENT VARIABLES						
			FEMALE STUDENTS			
Course Grade	22* additional hours for lower ability females		22* additional hours for lower ability females		0 additional hours needed by lower ability females	
Computer Lab Portion of Course	17* additional hours for lower ability females		13* additional hours for lower ability females		4 additional hours for lower ability females	
N= 21 average ability females 17 lower ability females						
			MALE STUDENTS			
Course Grade	20* additional hours for lower ability males		25* additional hours for lower ability males		22* additional hours for higher ability males	
Computer Lab Portion of Course	13* additional hours for lower ability males		27* additional hours for lower ability males		54* additional hours for higher ability males	
N=62 average ability males 65 lower ability males						

Note. Underlined numbers represent the estimated additional hands-on practice time required for average achievers to equal the performance of lower achievers, since in these cases lower achievers had higher estimated performance. All other estimates indicate the time required for lower achievers to match the performance of average achievers.

1 Estimated regression coefficients for time were used to calculate the additional hours needed to close the performance gap. Regression results can be obtained from the author.

* $p < .05$. A two tailed t-test was used to determine whether or not additional time required according to gender group would place the student outside the 95% confidence interval for the originally observed time spent on computers (by that gender group). For instance, the mean value of time spent in the lab for lower achieving female students was 68.453 hours with a standard deviation of 18.567. Thus, an additional 17 hours would be required for this group of female students to equate themselves with their female average achieving peers in the computer lab portion of this course (assuming that neither has received credit for the computing science course). This would imply a total time commitment of 85.5 hours (68.453 + 17) for these lower achieving female students, which is outside a 95% confidence interval of the originally observed mean (68.453). Consequently an adjustment in both time and student behaviour is required to equate the two academic ability groups.

Table 6

Additional Hands-On Practice Hours Required by Lower Achieving Female Students to Equal the Performance of Average Achieving Female Students[1]

	Lower Ability = Average Ability		Lower Ability = Average Ability		Lower Ability = Average Ability	
Previous Computer Course (CRBASIC)	NO	NO	NO	YES	YES	NO
DEPENDENT VARIABLES						
Doing Assignments using the Computer	21* additional hours for lower ability students		23* additional hours for lower ability students		2 additional hours for average ability students	
Performing Tasks with the Computer under Time Constraints	13* additional hours for lower ability students		2 additional hours for average ability students		16* additional hours for lower ability students	

N = 21 average ability females
26 lower ability females

Note. Underlined numbers represent the estimated additional hands-on practice time required for average achievers to equal the performance of lower achievers, since in these cases lower achievers had higher estimated performance. All other estimates indicate the time required for lower achievers to match the performance of average achievers.

[1] Estimated regression coefficients for time were used to calculate the additional hours needed to close the performance gap. Regression results can be obtained from the author.

* $p<.05$. A two tailed t-test was used to determine whether or not additional time required according to gender group would place the student outside the 95% confidence interval for the originally observed time spent on personal computers (by that gender group). For instance, the mean value of time spent in the lab for lower achieving female students was 68.453 hours with a standard deviation of 18.567. Thus, an additional 21 hours would be required for lower achieving female students to equate themselves with their female average achieving peers in the performing tasks with computer under time pressure portion of this course (assuming that neither has received credit for the computing science course). This would imply a total time commitment of 89.5 hours (68.453 + 21) for these lower achieving female students, which is outside a 95% confidence interval of the originally observed mean (68.453). Consequently an adjustment in both time and student behaviour is required to equate the two academic ability groups.

Table 7

Additional Hands-On Practice Hours Required by Lower Achieving Male students to Equal the Performance of Average Achieving Male Students[1]

	Lower Ability	= Average Ability	Lower Ability	= Average Ability	Lower Ability	= Average Ability
Previous Computer Course (CRBASIC)	NO	NO	NO	YES	YES	NO
DEPENDENT VARIABLES						
Doing Assignments using the Computer	4* additional hours for lower ability students		12* additional hours for lower ability students		11 additional hours for average ability students	
Performing Tasks with the Computer under Time Constraints	18* additional hours for lower ability students		45* additional hours for lower ability students		691* additional hours for average ability students	

N = 71 average ability males
75 lower ability males

Note. The estimated additional time required to equate groups underlined numbers is in terms of the second group's time, since the former group had a higher estimated performance. All other estimates are in terms of the first group's time required to equate themselves with the later group.

1 Estimated regression coefficients for time.

* $p<.05$. A two tailed t-test was used to determine whether or not additional time required according to gender group would place the student outside the 95% confidence interval for the originally observed time spent on personal computers (by that gender group). For instance, the mean value of time spent in the lab for lower achieving male students was 67.992 hours with a standard deviation of 19.389. Thus, an additional 18 hours would be required for lower achieving male students to equate themselves with their male average achieving peers in the performing tasks with the computer under time pressure portion of this course (a- 'ming that neither has received credit for the computing science course). This would imply a total time commit. .nt of 86.5 hours (68.453 + 18) for these lower achieving female students, which is outside a 95% confidence interval of the originally observed mean (68.453). Consequently an adjustment in both time and student behaviour is required to equate the two academic ability groups.

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List of Keywords and Phrases

academic ability
- performance
- previous computer course
- time effort

computer-literacy
- office setting
- traditional

end-user training
- efficiency
- time effort

gender effects
- performance
- time efforts

hands-on practising

knowledge
- declarative
- procedural

learning performance objective

evaluation criteria
- lecture performance
- hands-on performance
- assignments
- performance under time pressure

reference ability measures
- paper-and-pencil test

skill learning
- automatic processes
- controlled processes

task

teaching content
- technical
- theoretical
- skills

teaching methods
- lecture
- hands-on practice
- time pressure
- assignments

training