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ABSTRACT

This study examines the effects of academic ability (in average and lower ability students), gender, and teaching methods on students' acquisition of computer skills. Subjects were 247 college students who had completed a computer course using intelligent workstations in any one of six consecutive semesters. A combination of lecture and hands-on computer practice, the course was designed to teach generalized problem-solving and decision-making skills applicable to a number of settings. Multiple regression was used to determine the significance of factors and the magnitude of effect on the dependent variable in conjunction with the other variables, i.e., average academic ability as determined by the student's grade point average and grade on a previous computer literacy course. Dependent variables tested included the grades on the course, the lecture portion of the course, and the computer laboratory portion of the course. The major findings were that women, if given the opportunity to practice their skills, outperform men; and that the transfer of knowledge from a previous traditional computer course has only limited effect on performance, which can be compensated for by additional hours of practicing on the computer. The text is supplemented by four tables and six bibliographic notes. (35 references) (Author/EW)

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COMPUTER TRAINING AND TIME EFFICIENCY:
ASSESSING ABILITY AND GENDER EFFECTS ON LEARNING

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COMPUTER TRAINING AND TIME EFFICIENCY: ASSESSING ABILITY AND GENDER EFFECTS ON LEARNING

Abstract

Five hundred years ago, the invention of the printing press revolutionized information technology. Today, new information technologies are working equally profound changes in the ways business and industry are conducted. Effective training is the only way to ensure that these technologies are used to their full potential. This paper reports on a study done to determine how academic ability (in average and lower ability students), gender and teaching methods may affect student's acquisition of computer skills. Study findings reveal that women, given the opportunity to practice their skills, outperform men; and that the transfer of knowledge from a previous traditional computer literacy course has only a limited effect on performance for which additional hours spent practicing on the computer can compensate. Implications for computer training are discussed.

COMPUTER TRAINING AND TIME EFFICIENCY:

ASSESSING ABILITY AND GENDER EFFECTS ON LEARNING

The training of end-users for computer-based technologies is becoming increasingly important to all industrialized nations, especially since many employment opportunities for future generations will be created through the introduction of these technologies. Already, training has become one of the most important factors affecting the successful implementation of technology into organizations because only the effective use of technology really warrants the huge financial investment it requires. It is therefore disturbing that training research--which is neither sufficiently extensive nor up to date--frequently reports negatively on training efforts in organizational and educational settings. A recent study of employees from several organizations across the Western U.S. showed that hands-on experience and frequent computer use for certain job tasks did not necessarily constitute individual computer knowledge, let alone computer literacy (Gattiker & Larwood, 1986). The accusation that new technologies lower the quality of work life may stem from worker's frustrations over training they realize is inadequate (e.g., Bikson & Gutek, 1983).

That training is perceived as inadequate is perhaps no wonder; most training seminars used to teach workers how to utilize new technologies are compact workshops of one or two days which tend to overload the trainee with a large amount of information in a very short time. The problem is exacerbated by the varying skills and educational levels that exist in any organization's workforce. Generic courses that try to satisfy the diverse needs of such a group inevitably commit the proverbial crime of trying to please all, but failing to please any (Bikson & Gutek, 1983). Computer literate employees may find these seminars too general to be of any use, while individuals with little computer experience will be overloaded with technical details that cannot help them achieve the practical goal of applying their newly acquired skills beyond the immediate applications taught. At the post-secondary level most computer courses are the responsibility of computer science departments, which are usually more interested in advancing the technology than in teaching the application skills office end-users need. For the business graduate, however, the skills needed to work with computer-based technology in office settings are becoming a prerequisite for employment (Bikson & Gutek, 1983; Jones & Lavelli, 1986). Predictions estimate that by 1995 most aspects of end-user training will have to be covered by traditional educational institutions (e.g., Leontief & Duchin, 1986, chap. 4), so the present tendency to ignore the need for effective end-user training methods in educational systems is both intolerable and impractical.

In an attempt to provide information on more effectual end-user training strategies, this paper examines relevant research and documents a study seeking to identify factors that influence the aquisition of computer literacy[1] by individuals of varying levels of academic ability. Several training frameworks and the three components of training--training method, training content and training assessment--are discussed, with special emphasis on application skills for computers in an office setting.

The study this paper presents intends to answer three broad questions: (1) does previous computer exposure help lower achieving students in a later computer course equal the performance of the next highest academic group? (2) how many additional 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 or c) only the average achievers have this experience? (3) are these results similar for both males and females?

Literature Review

Effective Training

Literature on the effectiveness of computer training yields conflicting results and provides more unanswered questions than definitive answers about various training methods. Existing computer training techniques include lecture formats, practical "hands-on" approaches or combinations of the two, but the ability of any of these methods to facilitate the acquisition of computer skills remains to be discovered.

Training in an organizational context may be defined as any company-initiated procedure which is intended to foster learning among organization members. Learning, similarly, may be thought of as a process by which an individual's pattern of behaviour is altered in a manner which contributes to organizational effectiveness (Hinrichs, 1976). It has been suggested that training should use several methods to teach skills (Burke & Day, 1986). One of the most traditional means of presenting information is the lecture, which usually consists of a carefully prepared oral presentation on a subject by a qualified individual (Reith, 1976). The content of lecture-based training is conceptually and theoretically focussed, while drill-and-practice training emphasizes application of concepts and theories to solve problems in a possible work setting. Learning theory (Thorndike, 1913) suggests that the learning mechanisms involved in the drill-and-practice teaching method are association (built up through contiguity which is established via practice) and imitation (learned response tendency equals learned habit). Problem-solving assignments done independently will give students the necessary practice for an acceptable level of contiguity, while exams will help them to learn how to perform under time pressure. Imitation may be accomplished by having the student observe the instructor while he or she performs certain tasks. Feedback from these three elements will allow the modification of the student's behaviour and act as a reinforcer (Bandura, 1977).

Content of training. Most often, training is conducted at a terminal and involves the use of learning manuals. Unsurprisingly, employees who are least satisfied with the computer equipment are those who are expected to learn to use it with only a manual as a guide (Bikson & Gutek, 1983). Tornatzky (1986) stated that this sort of narrow skills training may be insufficient, and it seems to be true that computers are used most successfully in the workplace when employees understand the principles behind their machines as well as know how to operate them in a narrow technical sense.

Problem-solving/decision-making programs emphasize the teaching of generalized troubleshooting skills applicable to a wide range of problems that might be encountered within an organization (Campbell, Dunnette, Lawler, & Weick, 1970). As computers become more and more common in the workplace, effective troubleshooting will require a more comprehensive knowledge of computing. Today's business graduate should therefore 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).

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 by using either reference ability measures (usually paper-and-pencil tests) to appraise the theoretical and technical knowledge taught to individuals, or learning measures (usually simple information processing procedures designated as tasks) to determine the performance level attained by the individual in working with the computer (cf. Ackerman, 1987). Theoretically, tests and assignments give the student the feedback he or she needs to improve learning; additionally, they should also encourage students to be creative in problem solving to a level beyond that strictly required by the formal parts of the educational process.

The economics of training and time usage. For an 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 is to the benefit of students as well, since this will enable them to enter the job market more quickly. Time efficiency, unfortunately, is often dependent upon the information processes that are needed to perform a given test or task. 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 only 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 an examination, a resource intensive task which does not allow for automatic processing (Ackerman, 1987).

Individual differences and learning. Perhaps the fondest dream of the educator is to discover a method of training equally effective for all the members of a diverse group; since it is unlikely that this will ever happen, the effectiveness of equal training for such a group attempting to achieve computer literacy must be questionned. Though we might assume that former levels of academic achievement will have an effect upon subsequent performance when acquiring computer literacy, the effect may be less substantial in training sessions which allow for the development of automatic processing and which reduce resource intensive, controlled processes. In this sort of seminar, performance differences for high, average and lower ability students are unpredictable.

Research reports that homogeneous ability groups require less computer training time. The time required to achieve acceptable performance levels for higher ability individuals may be considerably reduced if they are grouped with peers of similar ability (Dossett & Hulvershorn, 1983). Unfortunately, such research does not report if the results apply for tasks with automatic components being developed during training, or for resource intensive tests which require the use of controlled processes.

Most research about computer training has concentrated on higher ability groups (Butcher & Muth, 1985). Moreover, the individuals who formed these groups were typically high school students attending an elective computer course and who thus represented 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 will not necessarily find them interesting and may even find them intimidating. Organizations and educational institutions must be concerned with effective and time-efficient methods of training these less able or 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[2] will facilitate the learning of "new" microcomputer skills, and research has indicated that such a transfer of knowledge may indeed allow the individual to improve his or her learning effectiveness (Bandura, 1977; Thorndike, 1913). Previous computer exposure also leads to a certain level of familiarity with the technology which may facilitate learning. An exposure to traditional computer skills often occurs in an academic setting. However, if learning about computers is embedded in social situations that people naturally encounter outside the classroom, later access to information learned in these situations will be even easier (Bransford, Sherwood, Vye & Rieser, 1986).

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 during computer training, and also suggested that they seemed to be more able than men to transfer knowledge gained in other subjects when trying to solve problems with a computer. It is therefore possible that lower achieving females are more effective than males in translating previously acquired traditional computer literacy into better performance in the computer course, and that they need less additional time than men to attain a level of performance similar to that of their more able peers of the same sex (cf. Ethington & Wolfle, 1986).

Dossett and Hulvershorn (1983) found that lower ability male students did not need much more time than their higher ability peers when using the "hands-on" approach to learning about computers. Given what has been said in the previous paragraph, it would be interesting to see if these results can be repeated for females.

Time spent using the equipment. Time spent learning a skill has often been identified as the most important factor for improving performance. For instance, Stanley (1980) found that the main variable which differentiated students with similar aptitude in mathematics was the amount of effort put into practice. Lower ability students who practiced three hours per week were found to achieve the same grades as average ability students who spent no time on homework (Keith, 1982). Since solving mathematical problems invites the use of automatic processes, it is likely that practice time leads to better performance in other subjects that involve such processes, such as word processing and spreadsheet work (cf. Ackerman, 1987). Practice may prove especially valuable to lower ability students who are, as research has shown, sometimes less able than higher ability students to access relevant information acquired earlier when confronted with a problem or new learning task (see Bransford, Sherwood, Vye & Rieser, 1986 for an extensive review). In the long run, additional time spent in might be more useful to these students than knowledge transferred from previous computer science experience (Gettinger, 1985). 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 (Dossett & Hulvershorn, 1983).

Summary

As illustrated by this literature review, our knowledge of training for computer-mediated work is limited. This study fulfills a need for additional work investigating the effectiveness of computer training for adults (cf. Menashian, 1986; Snow, 1986) instead of children. Three factors distinguish this paper from previous research. First, this study concentrates on assessing the effectiveness of multiple training methods on objective learning, using the lecture and problem-solving/hands-on teaching strategies. While answering a call by Burke and Day (1986) for more such research, this study is especially intended to expand management training literature into the computer domain.

The second factor distinguishing this article from earlier work is that objective measures for learning are used for each training method. In the past most research about computer learning has concentrated on one measure such as self-report surveys assessing literacy (e.g., Anderson, 1987). Additionally, former studies of computer training have not separated the different teaching methods used (see Hebenstreit, 1986; Lepper, 1985 for extensive reviews).

The third differentiating factor is this study's attempt to extend the known relationship between learning time and training performance (Gettinger, 1985; Natriello & McDill, 1986) to computer training. This study assesses the magnitude of additional time efforts for lower level participants and the potential time savings to be obtained by having previously acquired traditional computer literacy. The transfer of learning from previous computer courses and the relative effectiveness of different computer training methods, measured by their time efficiency, are also assessed.

Research I.sues.

This study examines the effectiveness of different training methods designed to teach individuals with less academic ability to work with computers. The basic objective is to learn more about how to achieve the best training results in the least amount of time.

This research attempted to answer the following questions:

Question 1. Does acquiring traditional computer literacy before entering a computer course using intelligent workstations[3] help students of both sexes to improve their performance in the course?

Question 2. To what degree can male or female students improve their performance by previously attending a computer science course?

Question 3. Car students of either sex with lower levels of academic ability close the performance gap to their more academically able peers of the same sex, by investing more time practicing on the computer?

Method

Subjects

A total of 247 students who had completed a computer course using intelligent workstations in any one of six consecutive university semesters was included in this study. This course is usually taken by third and fourth year undergraduate management students and is designed to impart a degree of computer literacy to students so that they may be more effective in a work environment employing computers. Of this group, one-third were female and slightly over 40% of the total population had previously taken a computer science course. About 20% of the students work full-time and study part-time, 30% work part-time while attending university full-time, and approximately 75% of the students major in business administration.

The students are expected to spend between six and twelve hours studying for the class during a week; between 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 this course.

Historical information about each student's cumulative grade-point average, whether or not he or she had successfully completed (received a "D" or better) the optional mainframe computing course and the performance information for the course under study was obtained from the registrar's office.

To form similarly sized groups of equal academic ability, it was necessary to rank the 247 students 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 put into group one. The next 33.29%, the average ability students, were put into group two, and group three consisted of the remaining 33.29%, the lower ability group. Each of the three groups consisted of 82 students with GPA breaking points at 2.94, 2.48 and 1.92 (i.e., group 3 GPA 1.92 => 2.48). One student failed the course[4].

For this study, only data for group 2 and group 3 (n=171) were used. This reduced the number of women in the sample to about 1/5 since most women belonged to the high ability group.[5] Only average and lower academic ability individuals' performances were studied because some research indicates that learning strategies are different for highly able students (Biggs & Kirby, 1984; Snow, 1986). Furthermore, a greater range of teaching methods may be necessary to help less able individuals increase their competency to a satisfactory level (Gattiker & Paulson, 1987).

Definitions of Training Content, Training Methods and Criteria

As suggested by Tornatzky (1986), the content of this computer course is designed to provide students with knowledge and understanding of the principles of intelligent workstations and of the larger systems in which they often play a part. The emphasis is on teaching generalized problem-solving and decision-making skills that are applicable to a wide range of work problems that managers encounter. To accomplish this, the course uses both lectures and hands-on computer practice. The objective of the lecture portion of the course is to give the participant some technical knowledge concerning makes of computers, flowcharting, system design and mainframe and 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. Skills needed to use the local area network electronic mail and to up and download data to and from the mainframe computer are introduced. Students are also taught BASIC to enable them to instruct the computer in a programming language. 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 computer. The lecture portion and the lab portion each count for 50% of the overall course grade.

Many of the students in our subject class had previously attended the introductory mainframe computer science course offered by the same university. Because we are concerned about the effects that attending this course has upon the performance of these students, the course purpose and content shall be briefly discussed at this point. The objective of this mainframe 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, and a working knowledge of calculus and algebra is a prerequisite.

Since the mainframe course is likely to increase the students' keyboard skills--a side effect of the 80 to 140 hours of computer exposure gained by individuals with this experience--a certain transfer of knowledge should occur (cf. Thorndike, 1913). BASIC is another common factor between the two courses, and a certain amount of the technical knowledge taught in the computer science course is also likely to be applicable to the course under study. An examination of the benefits gained in the mainframe computer course may help course planners to compare the value of the theory learned in the computer science course with the importance of practice time in the course using intelligent workstations.

<u>Statistics</u>

All of the computational analyses were performed on microcomputers using the SYSTAT statistical package. Multiple regression was used so that the significance of factors could be determined and the magnitude of effect on the dependent variable in conjunction with the other variables could be inferred (Kamenta, 1971, pp. 374-376). The models for the overall, lecture and assignment 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 distributed (bivariate and multivariate normal distribution). To test this assumption, the data used in each of the regression runs were tested for data outliers first by looking at standardized residuals, and then by evaluating a histogram of the standardized residual plots. Analysis of these two procedures, and the normal probability plots of the standardized residuals obtained, showed that the data collected met the normal distribution assumption.

The coefficients obtained via these regressions and the observed mean values (e.g., time spent practicing with the computer, GPA and overall course grade) were used to calculate the additional practice time needed to close the performance gap between the different student groups. These results will be discussed in detail in the sections below.

To examine the effect of grouping the students based on their previous GPA and gender we performed regressions for each group separately and executed a Chow test6. The results suggest that grouping the students in this way 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 practicing computer skills was needed for an 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 Kamenta, 1971).

Results

To facilitate comparisons and subsequent discussions, the results of this research have been divided into three sections according to the research questions posed previously.

Student Performance in the Computer Course

The first research question asked if acquiring previous traditional computer literacy helps students of either sex to improve their performance in the computer course studied. The results in Table 1 indicate that the average academic ability male students with a previous computer course benefit significantly in the lecture as well as the lab portion of this course. Lower academic ability male students benefit only in the lab portion of the course if they have taken a prior mainframe course.

Insert Tables 1 & 2 about here

For the females, the results were very different. The effect recorded for the lecture and the lab portions of the course were not significant (although the lab effect was close at ($p<.06$)), but a significant effect was discovered for average academic ability females in the overall course grade. In contrast, lower academic ability females do not benefit from this additional exposure significantly.

Based on these results, question 1 cannot be answered positively for all students since not all individuals are able to transfer previously acquired traditional computer literacy into higher performance in a subsequent computer course.

<u>Student Performance and its Relationship to Gender and Academic Achievement</u>

The second question posed in this study asked to what <u>degree</u> male or female students improve their performance by previously attending a computer science course. To investigate this issue further, observed values (cf. Table 3) and the regression coefficients obtained earlier (cf. Tables 1 & 2) were used to calculate the estimated values for each respondent group. Only the underlined and bold results in Table 4 are statistically significant based on the earlier regression analyses (cf. Tables 1 & 2).

The results, as shown in Table 4 (e.g., female course grades from

2.536 to 3.788), indicate that the estimated performance levels for average ability students of both sexes improve considerably if they have previously attended a traditional computer literacy course. Most interestingly, average ability women transfer knowledge already acquired in a mainframe course and increase their overall performance in a later computer course to a greater extent than males. Based on the earlier Chow test it was already shown that these gender effects were statistically significant.

Insert Tables 3 & 4 about here

The results demonstrate that the academically weaker participants gain from additional computer exposure previously acquired in a course teaching traditional computer literacy. The effects on their microcomputer performance, however, are different based on their gender. A cautionary note is necessary. Only the effect recorded for the computer lab portion of the course for males is statistically significant (cf. regression coefficient in Table 1, 7.135). The other effects are not statistically significant and should therefore be taken with some caution even though the magnitude of the differences between having and not having previous traditional computer science exposure is substantial.

Effort and Performance

The final question inquired if performance differences between students of lower and average academic ability can be reduced by increasing practice time on the computer. Or in other words, do the benefits of practice outweigh the limited value of previous exposure to traditional computer literacy? If so, the time needed to pass the mainframe course is not justified. Given the results obtained for Question 1, it would seem more efficient to invest more time practicing in the present course than to take a traditional course first.

The last column of Table 5 indicates that for female students in the lower academic ability group no real adjustment in learning behaviour (i.e. time spent) is required to equate themselves with the average academic ability females.

Insert Table 5 about here

The results are quite different for male students. Even having previously attended a computer science course teaching traditional literacy, male students with lower academic ability must significantly adjust their behaviour to equate themselves with the male average academic ability group. For the lecture portion an additional 82 hours is required to do so, and the computer lab portion of the course required 54 extra hours. The results suggest that question 3 can be answered positively. Additional time spent practicing skills helps lower ability students of both sexes to close the performance gap.

Previous exposure to a traditional computer literacy course results in lower academic ability women having to invest less time than their male peers to attain the average academic ability competency levels of their female peers. One explanation for this could be the larger time coefficients (Tables 1 & 2) obtained for females which show that males are less effective in transferring time effort into higher performance.

The results in Table 5 also demonstrate that the additional exposure gained by acquiring traditional computer literacy first may not be worth the effort. It is obvious that both female and male students of the lower academic ability group may be better off spending more time using computers rather than attending a course teaching traditional computer literacy. The data also illustrate that the time effort needed by lower academic ability women to close the performance gap to their peers in the course is lower than for men, independent of attendance in a former computer science course.

Discussion

The primary purpose of this study was to expand the issue of training effectiveness into the computer domain by examining if individuals of lesser academic ability would be able to use knowledge acquired through previous computer exposure to improve their subsequent learning performance. Additionally, the study investigated whether the performance gap between medium and lower ability students could be reduced by an additional time effort put into practicing computer skills. Lastly, the study used various objective performance measures to assess which teaching method (lecture versus lab) would be more beneficial to lower ability students.

The most important result of this study is the fact that transfer of knowledge acquired in a previously attended computer science course appears to be limited. Some transfer of knowledge effects can be reported for average academic ability men and women, but for the lower ability participants of both sexes transfer of knowledge from the previous computer science course was non-existent for all practical purposes.

One explanation for these results may be in the different teaching goals of the computer science course versus the class used in the study. The latter attempts to resemble work situations which require problem solving with the help of the computer, while the computer science course creates a more technical and research oriented environment. Transfer of knowledge from one to the other is, therefore, very difficult since the two courses use detrimentally opposing teaching goals. Students may not have really understood how the information acquired in the computer science course could function as a tool to help solve problems in the later computer class (cf. Bransford, Sherwood, Vye, & Rieser, 1986). Transfer of knowledge would thus be inhibited.

Although it is slight, the estimated performance levels as calculated in Table 4 show, however, that some transfer of knowledge is apparent. For instance, men benefit in the practical section of the course. One reason for this result could be that typing is usually stigmatized for males and their keyboard skills tend to be limited when they enter their first computer course. Stroking speeds should, however, be faster if the male student has some computer experience acquired in a previous course. Future research needs to establish if differences in stroking speeds between women and men may in part explain these differences in transfer of knowledge effectiveness.

It would be to an organization's greatest benefit if programs were designed to allow participants to complete training as soon as possible. The data in this study indicate that time efforts are less for lower ability students in the practical portion of the course than in the lecture part, and confirm the notion raised by others (e.g., Bikson & Gutek, 1983; Bjorn-Anderson, 1983) that acquiring traditional computer literacy may not be helpful to improve effectiveness in an office setting using intelligent workstations. Thus, training for practical skills would be most time efficient. Using Tornaztzky's (1986) proposition one would have to argue however that theoretical knowledge and some technical background are needed to use technology effectively in the workplace.

Since both lecture and lab are arguably needed to accomplish effective computer training, the question of which method is more effective for teaching computer literacy may not be an issue. Instead, the issue may be how technical and theoretical skills can be taught to lower ability students in the least amount of time. One feasible possibility might be to have study labs for the theoretical part of the course for these individuals (cf. Dossett & Hulvershorn, 1983). Thus, less able students would get the additional learning and exposure they need to allow the attainment of a level of knowledge comparable to medium ability students.

One possible limitation of this study is the fact that no data was obtained about how individuals practiced their skills. For instance, using more time to practice word-processing instead of programming may have had some effects on the training outcomes. Moreover, no data was obtained about individual study habits for the lecture portion of the class. Future research should investigate this further and should also try to replicate the results obtained in this study, using different samples in different settings (universities, continuous education and company seminars).

Conclusions

How does this study advance previous research about training effectiveness in the computer domain? This study used adults as subjects to rectify what has been cited as one of the greatest faults of most research in this field (Hebenstreit, 1985; Menashian, 1985). Furthermore, the sample represents individuals who are not especially interested in computers while previous research has usually concentrated on those who are (Anderson, 1987; Lockheed, Nielsen & Stone, 1985). Thus, the results reported are for the sort of individuals that organizations are most likely to have to train to work effectively with computers in office settings.

Foremost, this study shows that reported sex differences are not really of great magnitude. The justification for the emphasis put on gender differences in earlier research is brought into question (e.g., Anderson, 1985; Reece & Owen, 1985). While it is true that each group may have to cope with different disadvantages (men = keyboard skills and women = sex role stereotyping), these can be offset by experience and subsequent training success (Campbell, Dunnette, Lawler, & Weick, 1970; Hinrichs, 1976).

This study raises an important issue for computer education policymakers in business schools. Teaching technical, theoretical and practical aspects of computing can only be effective if it facilitates access of the relevant information when students are out of the classroom and on the job (Jones & Lavelli, 1986). Hence, computer training must pay attention to the types of work situations that people naturally encounter once they leave the classroom (Lepper, 1985). This could also explain why computer science training may not help the transfer of knowledge to improve performance in computer application courses. Skills and knowledge taught in such training may not represent the situations naturally encountered by people working in office environments. Thus, business schools need to provide their own computer courses to assure adequate training of their graduates.

Training content has not been given enough attention in the past. Until recently, most computer training has had a strong technical focus (Bjorn-Anderson, 1983). Now, the penetration of computers into offices requires that end-users attain a literacy level sufficient to use computers efficiently in their work. As this study suggests, traditional computer literacy may not meet the needs of office end-users (cf. Campbell, Dunnette, Lawler, & Weick, 1971; Dossett & Hulvershorn, 1983). Since traditional literacy content has proved insufficient, future research should determine how to make course content effective. For example, researchers could investigate differences in learning performance that occur if the sequence of training (e.g., DOS, WordPerfect and Lotus) is altered. The sequence used in this study may not be the best. Furthermore, running a practical section (hands-on) previous to the lecture (theory and technical knowledge) portion of the course may be more effective than running both concurrently as done in this study.

Study data show the importance of abundant practice to increase training effectiveness for lower ability students. This finding has two practical repercussions. For full-length courses, students need easy access to computers to adequately practice skills. For compact courses given in one or two days, their value is brought into question. Short seminars often attempt to teach technical and theoretical knowledge and promote innovative use of the technology, but fail to provide sufficient time for individual practice and reflection (Natriello & McDill, 1986). Thus optimum effectiveness is not obtained.

As well as we can determine, this is the first serious, albeit narrow, statistical investigation of a research stream into the computer training paradigm using adults and a combination of lecture and practice teaching methods. Additionally, this study uses objective measures, in contrast to earlier work which has typically used self-report survey methods to assess literacy outcomes after training. This study clearly indicates that time efforts for lower ability students are substantially higher than their average ability peers. From an organizational perspective this suggests that different ability groups should be trained separately. Future research should also investigate if attitudes held toward computers are different for various groups and the potential effect this may have upon training performance. For instance, Gattiker and Nelligan (1988) found when surveying office workers that women held more positive attitudes toward computers than men. It is reasonable to assume that this should have a positive effect upon training. We hope that the understanding of computer training effectiveness and its relationship to instructional methods and demographics as presented in this study will be useful in the future development of theories and applications.

Notes

1) Computer literacy for intelligent workstations requires the individual to have certain skills, such as the ability to use software packages for various applications (eg., word-processing, spreadsheets, data-base management and graphics). Therefore, in this paper, such literacy is consideredsynonymous with certain skills.

2) Traditional computer literacy requires that an individual has interactive skills applicable to main-frame computers, such as knowledge of a programming language like BASIC, sequential files, algorithms, programs, flowcharts and the ability to find solutions to elementary numeric problems with computers. In this study, it is assumed that if a student has previously attended a computer science course, he/she has acquired the above skills as outlined in the course description.

3) An intelligent workstation is defined here as a microcomputer which is part of a local area network, allowing communication and data transfer to and from various computers (e.g., mainframe, minis and other microcomputers).

4) The grade distribution of the sample used for grouping the students represents the general grade distribution of the university. Although grade-point average is not a perfect measure for assessing academic ability it has been used extensively because of its simplicity and to facilitate comparisons with other studies.

5) The literature suggests that if a small sample has the same

asymptotic unbiasedness properties as large samples do, there is no problem when using small samples to test 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; Kennedy, 1979, pp. 18-21). The sample drawn in this study meets these assumptions.

6) To test whether grouping of variables according to gender was justified, we also performed regressions for both groups combined and did a *Chow* test. The results suggest that the grouping of students based on gender leads to significantly different regression coefficients, $p<.05$.

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Table 1

Regression Results Of Male Students Grade, Lecture Portion and Computer Lab Portion of Course

INDEPENDENT VARIABLES[1]

Dependent Variable	-Constant	Average Academic GPA	Lower Ability[2] GPA	Previous Comp. Course Academic Ability[4] Average	Lower	Average Academic HRS	Lower Ability[5] HRS	F[6]	df	R^2
Course Grade	-.216	.872	.697	.557	.247	.002	.010	8.84**	127	.46
	(-0.41)	(4.00)*	(2.50)*	(3.34)*	(1.54)	(0.77)	(2.20)*			
Lecture Portion of Course	49.754	8.476	8.840	4.963	-.425	-.003	.019	5.29**	127	.34
	(7.84)*	(3.24)*	(2.64)*	(2.47)*	(-0.22)	(-0.07)	(0.35)			
Computer Lab Portion of Course	37.313	11.106	5.473	6.400	7.135	.067	.268	11.87**	127	.53
	(5.66)*	(4.08)*	(1.57)	(3.07)*	(3.57)*	(1.72)	(4.69)*			

Note. To examine whether grouping the students based on their previous GPA mattered in this table, we also performed regressions for each group separately and performed a Chow test. The results suggest that the grouping of students based on previous GPA leads to significantly different regression coefficients, $p < .05$. 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.

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

[2] The grade point average that the student had attained upon entering the micro-computing course.

[4] A dummy variable for completion (1=passing grade, 0=failing grade or not attended) of the university's computer science course teaching traditional computer literacy.

[5] Total number of hours the student used the microcomputer facilities throughout the semester to practice and learn new skills. Each time the student used the microcomputer this was recorded by a computer program.

[6] F-ratio obtained for the regression with $**p < .01$.

Table 2

Regression Results of Female Students' Grade, Lecture Portion and Computer Lab Portion of Course

INDEPENDENT VARIABLES[1]

Dependent Variable	-Constant	Average Academic GPA	Lower Ability[3] GPA	Previous Comp. Course Academic Ability[4] Average	Lower	Average Academic HRS	Lower Ability[5] HRS	F[6]	df	R^2
Course Grade	-3.547	1.982	1.643	1.252	.540	.009	.025	3.59**	26	.60
	(-1.47)	(2.22)*	(1.63)	(3.76)*	(1.69)	(1.39)	(2.85)*			
Lecture Portion of Course	32.309	13.967	14.341	6.089	3.716	.077	.102			
	(1.08)	(1.27)	(1.15)	(1.48)	(0.94)	(0.92)	(0.95)	3.16**	26	.57
Computer Lab Portion of Course	31.802	10.420	-1.274	9.312	6.479	.144	.493			
	(0.95)	(0.84)	(-0.09)	(2.01)	(1.46)	(1.53)	(4.07)*	2.77**	26	.54

Note. To examine whether grouping the students based on their previous GPA mattered in this table, we also performed regressions for each group separately and performed a Chow test. The results suggest that the grouping of students based on previous GPA leads to significantly different regression coefficients, $p<.05$.

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

[3] The grade point average that the student had attained upon entering the micro-computing course.

[4] A dummy variable for completion (1=passing grade, 0=failing grade or not attended) of the university's computer science course teaching traditional computer literacy.

[5] Total number of hours the student used the microcomputer facilities throughout the semester to practice and learn new skills. Each time the student used the microcomputer this was recorded by a computer program.

[6] F-ratio obtained f the regression with $**p<.01$.

Table 3

OBSERVED VALUES FOR THE DIFFERENT 'GENDER GROUPS'

	Average Ability Students		Lower Ability Students	
	MALE	FEMALE	MALE	FEMALE
Mean GPA[1]	2.667	2.726	2.260	2.327
Mean HRS[2]	66.839	72.519	67.992	68.453
S.Dev. HRS	27.708	22.136	19.389	18.567
Num. of obsv.[3]	61	21	65	17

[1] Grade-point average the student acquired before taking this course. Continuous scale from 1 (lowest) to 4 highest).

[2] Average number of hours students did practice and drill in the microcomputer laboratory. The amount of time was recorded by lab proctors and clocking devices.

[3] 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. The literature suggests that if the small sample has the same asymptotic unbiasedness 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; Kennedy, 1979, pp. 18-21). The sample drawn in this study meets these assumptions.

Table 4

ESTIMATED PERFORMANCE LEVEL BY EACH ACADEMIC ABILITY GROUP[1]

DEPENDENT VARIABLE	No Previous Computer Course Average Academic Ability	No Previous Computer Course Lower Academic Ability	Previous Computer Course Average Academic Ability	Previous Computer Course Lower Academic Ability
		FEMALE		
Course Grade[2]	<u>2.536</u>	1.988	<u>3.788</u>	2.528
Lecture Portion of Course[3]	76.198	72.663	82.287	76.379
Computer Lab Portion of Course[4]	<u>71.082</u>	62.585	<u>80.394</u>	69.064
		MALE		
Course Grade[2]	<u>2.243</u>	2.039	<u>2.800</u>	2.286
Lecture Portion of Course[3]	<u>72.159</u>	71.024	<u>77.122</u>	70.599
Computer Lab Portion of Course[4]	<u>71.411</u>	<u>67.904</u>	<u>77.811</u>	<u>75.039</u>

Note. The underlined figures represent the statistically significant change in performance levels for males and females who have previously attended a course in traditional computer literacy.

[1] These values have been predicted by using the observed mean values found in Table 3 and the multiple regression equations/coefficients from Table 3.
[2] Grade-point the student acquired in the microcomputer course. Continuous scale from 1 (lowest) to 4 highest).
[3] The number of points achieved by the student using this teaching method out of a possible maximum of 100.
[4] The number of points achieved by the student using the drill and problem-solving teaching method out of a maximum of 100 points.

Table 5

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

DEPENDENT VARIABLE	Lower Achievers = Average Achievers	Lower Achievers = Average Achievers	[illegible] Achievers = [illegible] Achievers
Previous Computer Course	NO NO	NO YES	YES NO
		FEMALE STUDENTS	
Course Grade	22*	22*	0
Lecture Portion of Course	35*	36*	2
Computer Lab Portion of Course	17*	13*	4
		MALE STUDENTS	
Course Grade	20*	25*	22*
Lecture Portion of Course	60*	27*	82*
Computer Lab Portion of Course	13*	27*	54*

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 (see Tables 1 and 2) for time were used to calculate the additional hours needed to close the performance gap.

* $p<.05$. 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 microcomputers (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.