# The Effectiveness of Using Computers for Software Training: An Exploratory Study

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**ABSTRACT**

Both academic institutions and corporations have invested huge amounts of resources in computer-based training and education. The evidence in support of the effectiveness of computers and instructional technology in the classroom is mixed at best, and much of the practice is based on faith and ongoing trends in education. In this study, we conduct an exploratory experimental investigation into the effectiveness of four computer-based software training methods; traditional, delayed, asynchronous, and synchronous. We do not find any evidence to support the commonly held beliefs that there is an improvement in the computing literacy scores of students if the instructor has access to computers or if the students have access to computers during the software lesson. On the other hand, students find the practice of using computers both by themselves and by the instructors more satisfying than not being able to use them in the classroom. Our results have serious implications for instructors and decision-makers in both education and industry. While our results are directed at the lower levels of the Bloom's taxonomy of learning, we recommend research into higher levels in order to assess the full impact of computer-based education.

**Keywords:** Computer-Based Education, Software Training, Learning Methods, Computer Literacy, Instructional Strategy

## 1. INTRODUCTION

With rapid advances in computer-based instructional technologies; the advent of the Internet and the World Wide Web; the exponential growth in the performance of computers and computing devices; and constantly declining prices, there has been a dramatic growth in computer-based teaching and learning in the last decade (Alavi & Leidner; 2001). Despite this growth, the effectiveness of learning through computer based education remains uncertain. While the systematic evaluation of innovative computer-based instructional practices is a prominent topic in higher education research, empirical results have found mixed and conflicting results regarding their learning outcomes. The evidence in support of effectiveness of instructional technologies is weak at best, and much of the practice is based on faith and ongoing trends in education. Some recent examples of empirical research are offered in evidence of the above argument. In their commentary, Alavi & Leidner (2001) reviewed past research and observed either significant differences in outcomes across studies or insignificant differences. Furthermore, many results were contextual and could not be generalized. Young, et al. (2003) observed that when analyzed relative to other learning factors, technology's influence is secondary. Sweeney & Ingram (2001) found that face-to-face tutorials were most highly rated in terms of effectiveness than asynchronous (bulletin boards) or synchronous (chat rooms) web-based approaches. McLaren (2004) noted that while there are significant differences in persistence (for learning) among online students and traditional students, there was no difference in performance. Rankin and Hoass (2001) addressed the question of what effect the use of PowerPoint presentations has on students' performance and found no significant effect. Cybinski and Selvanathan (2005) even found that a flexible learning approach using a computer-managed learning tool and with minimal face-to-face teaching generated student anxiety and may be inappropriate for teaching undergraduate statistics. Clouse and Evans (2003) experimented with four treatments comprising of synchronous and asynchronous lectures and discussion; three of the treatments resulted in similar performance and one had decidedly poor results. On the other hand, Webb (2005) observed that students in the online environment may perform better at multiple levels of outcome, especially when using a blend of classroom and online technologies.

Given the confounding nature of the results of the past studies, this study investigates alternative modes of computer-based education and their effectiveness. We selected "using computers for software training" as the domain for our research. The traditional method for software training used to be classroom lectures by the instructor followed by labs, tutorials, and homework assignments. Following the advances in computer and instructional technology, several alternative methods have been utilized. One of the key elements of the computer-based approaches is the in-class use of the computer by the instructor and/or the student. We build on this concept to develop several computer-based scenarios for software training and then test their effectiveness using an experimental approach.

## 2. AN EVALUATION FRAMEWORK FOR COMPUTER-BASED SOFTWARE TRAINING METHODS

There are three phases in the training/learning process: the initiation phase for needs assessment and the design and development of appropriate training materials, the formal training and learning phase concerned with the actual training or teaching methods used, and the post-training phase which examines the learning effects of the teaching method (Compeau et al. 1995). Our focus is primarily on the training and learning phase, and its impact on learning (Yi and Davis 2001). Note that many training and learning methods exist, for example: hands-on use, behavior modeling, exploratory learning, different modes of delivery (e.g., face-to-face, video, audio, and computer-based), and choice of the facilitator (e.g., outside consultants, in-house trainers, and self-training).

Based on many previous writings (e.g., Yi and Davis 2001; Alavi & Leidner; 2001; Arbaugh 2000; McLaren 2004; Goodhue 1998), we adopt the following framework depicted in Figure 1 for evaluating the effectiveness of computer-based software training methods. The central premise of the framework is that any method of learning or training (the terms "learning method" and "training method" have been used interchangeably. The former is from the perspective of the student subject whereas the latter is from the perspective of the instructor) in either an individual or group setting will be effective based on the characteristics of the student subject and the nature of the task. Goodhue (1998) developed an instrument based on task-technology fit theory in which the correspondence between IS functionality (i.e., the training method), individual characteristics (i.e., the subject profile), and task requirements leads to positive affective outcomes and performance impacts. We describe below the various components of our framework.

### 2.1 Subject Profile

Several subject characteristics have been investigated by prior researchers as the determinants of the quality of learning. These include demographic characteristics like age, gender, ethnicity, education, and experience (Bowman et al 1995; Grupe & Connolly 1995; Yi & Davis 2001; Sweeney 2001). Cognitive characteristics, such as learning styles and personality attributes of individuals have also been examined in the literature (Clouse & Evans 2003; Schniederjans & Kim 2005). Grupe and Connolly (1995) emphasized the need to customize training methods for adults to suit their needs, behavior and learning styles. The effects of training method and individual differences on learning performance and computer self-efficacy in WWW Design Training have been the focus of the article by Chou,Huey-Wen (2001). Bostrom (et al 1990) make recommendations for software training methods based on four end-user learning styles: converger, assimilator, diverger, and accomodator. Overall, while demographic characteristics do not generally seem to affect learning outcomes, differences have been found based on education, experience, and cognitive characteristics.

### 2.2 Task Characteristics

Task characteristics can have a significant impact on the choice of the training method as well as the learning outcomes. In our context, task refers to the material or lesson that is being taught. Included among task characteristics are: type, size, scope, and complexity. The role of task has been addressed in the IS literature in the context of decision environment of DSS and group systems. Task taxonomy for learning can have various dimensions, e.g., the subject matter (e.g., the physical sciences or the social sciences), the IT-relatedness of the task (e.g., software training), and the complexity and scope of the material. Task complexity, scope and size have been shown to affect performance tasks in the decision making environment (e.g., Guimares et al, 1992; Swink 1995; Bolt et al 2001). Swink (1995) included different problem sizes and scopes in order to compare the relative effects of task variables on decision performance. In analyzing learning effectiveness, different researchers tend to use different tasks thus making comparison across studies difficult. In fact, Bolt et al. (2001) introduced task complexity as an important determinant of learning performance within the same training method. It can be argued that learning is situational or task dependent, and a subject may prefer one learning method for one task and another for a different task.

### 2.3 Performance Outcomes

Performance outcomes can be classified into two categories: cognitive learning and skill-based learning (Yi & Davis 2001). The first one refers to acquiring knowledge in a particular domain, while the second one refers to hands-on proficiency in utilizing a certain product or service. Generally all performance measures used by previous researchers can be classified under these categories. While the specific measures may vary, researchers have called for multiple levels of outcomes (Webb et al. 2005; Rungtusanatham et al; 2004, Young et al. 2003). These categories can also be related the various levels of the well-known Bloom's taxonomy of learning (Bloom 1984). Generally in literature, we have found the mention of computer literacy as being all inclusive of the knowledge and skills component of computers. According to the Wikipedia dictionary (accessed on January 19, 2007), "*Computer literacy"' is the knowledge and ability to use computers and*

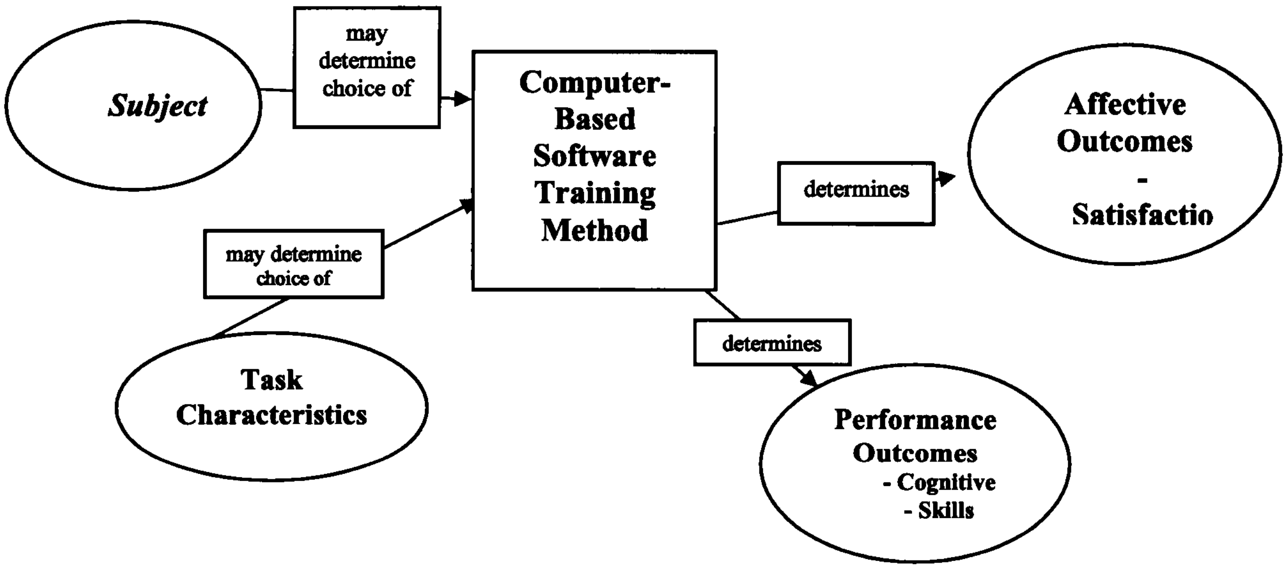


**Figure 1: An Evaluation Framework for Computer-Based Software Training Methods**

*technology efficiently. Computer literacy can also refer to the comfort level someone has with using computer programs and other applications that are associated with computers. Another valuable component of computer literacy is knowing how computers work and operate."* Generally, "computer literate" often connotes little more than the ability to use several application software like word processing, spreadsheet, e-mail, and the ability to surf the Internet. Sometimes, computing literacy is used analogously to computer literacy. Halaris and Lynda (1985) defined computing literacy as including universal competencies, subject-specific competencies, and stages of computing literacy. Essentially, they include all the components of knowledge about computers and skills needed to use computer applications effectively. Based on the dichotomy suggested by Yi and Davis (2001), we like to draw a distinction between computer literacy (cognitive skills) and computing literacy (skill based learning). Simply stated, computer literacy refers to the knowledge about computer fundamentals (hardware, operating system, bits and bytes), where as computing literacy refers to the skills needed for using computers. Our research focuses on computing literacy.

**2.4 Affective Outcomes**

Affective outcomes have value in their own right and can sometimes be used as surrogates for performance measures, especially when it is difficult to measure the performance outcomes. This is true of not only research in computer-based education but also in research related to the effectiveness of information systems in general. For example, instruments have been developed to measure end user satisfaction (e.g., Bailey & Pearson 1983; Ives et al., 1983; Doll and Torkzadeh 1988) and behavioral intentions (Davis 1986; Davis et al., 1989). In the domain of computer-based education, a common measure that is used is student satisfaction with the training method. Yi and Davis (2001) called this an affective outcome and used an instrument developed by Davis (1989) to assess the perceptions of the system's usefulness and ease of use. Arbaugh (2000) examined student satisfaction based on the impact of technological and pedagogical characteristics of a virtual classroom; the sub-constructs included perceived usefulness and perceived flexibility. Satisfaction has been repeatedly used in the IS literature and we include it as an affective outcome in this study. While satisfaction itself includes several perceptions such as perceived usefulness and perceived ease of use, other perceptions include perceived learning, perceived flexibility, anxiety, and enjoyment (Benbunan-Fich 1999, Sweeney & Ingram 2001; Stoel & Lee 2003; Cybinski & Selvanathan 2005). A review of past studies shows that they often evaluated: (a) cognitive outcomes by measuring comprehension of declarative knowledge, (b) skills-based outcomes for task performance, and/or (c) affective outcomes by measuring satisfaction and perceptions of system's ease of use and usefulness. We describe each component of the framework briefly.

**2.5 Computer-Based Software Training Method**

Many computer-based training methods have been investigated in prior research. These include the use of PowerPoint presentations, online discussions, web-based courses, virtual classroom, synchronous and asynchronous lectures, distance learning, and the like. Before the dawn of computers, the traditional method was lectures by the instructor followed by labs, tutorials, and homework assignments. As an example, an instructor can teach the basics of software utilizing traditional teaching tools like chalkboard, handouts, easel board, overhead transparencies, and handouts followed by students practicing in a computer laboratory. Following the advances in computer technology, institutions began computer-based demonstration of the important features of software in the classroom, with or without the aid of traditional teaching. After the demonstration, students can practice in the computer labs. During the 1990s, institutions have begun utilizing interactive computer labs where students practice concurrently what the instructor is demonstrating on the computer. Leidner and Jarvenpaa (1993) articulate the importance of electronic classrooms in the 1990s. Another significant development has been in the area of computer-driven or computer-assisted software learning. In this approach, students learn at their own pace without the instructor. However, several studies have demonstrated the importance of instructor led training. Danziger Jim and Yee Eric (2000) found clear preference (60%) for instructor led training based on responses from 400 sophisticated end users who are engineers, planners, managers from a large multinational company who reported on their own training and learning experiences. Given this clear preference, we focus on different instructor led computer-based methods for software training, and more specifically on spreadsheet software training. Below (Figure 2) is a framework for classifying computer software training methods in a group setting (i.e., a classroom). Within the framework, we analyze the effect of two factors on the instruction process: the students having concurrent access to computers in the classroom, and the instructor having access to computers. Accordingly, there are two dimensions to classify software training methods in a group setting. The first dimension allows for the students to have or not have computers during instruction for immediate practice. The second dimension allows the instructor to have or not have a computer for immediate demonstration at the time of instruction. Past research has not explicitly looked at the combination of these two factors which in effect generates four training methods, as described below.

- **Traditional:** The instructor teaches in the traditional mode without access to computers, lectures, uses chalkboard, and answers students' questions. The students do not have access to computers during the lecture. They take notes and ask questions. Since it is software training, they get to practice on the computer after the lecture.
- **Delayed:** The instructor teaches with hands-on demonstration on the computer. The students listen and take notes without access to computers. They practice on the computer after the lecture.
- **Asynchronous:** The instructor teaches in the traditional mode without access to computers. The students practice concurrently during the lecture using computers.
- **Synchronous:** The instructor teaches with hands-on demonstration on the computer and the students practice concurrently during the lecture using computers.

## 3. RESEARCH DESIGN AND HYPOTHESES

The above discussion and the four training methods lead to a 2 x 2 factorial design. There are two independent variables: the instructor's access to computers and the students' access to computers during instruction. Each of them is at two levels. There are three variables measured within each cell: the computing literacy score before the training, the computing literacy score after the training, and the satisfaction with the training method. The improvement in computing literacy is obtained by subtracting the "before" score from the "after" score. Improvement in computing literacy (CCL) and satisfaction (SAT) are the dependent variables in formulation of the following hypotheses:

**H1:** Each training method results in a change in computing literacy (CCL). The four sub-hypotheses are:

**H1a:** The traditional software training method results in a positive CCL.

**H1b:** The delayed software training method results in a positive CCL.

**H1c:** The asynchronous software training method results in a positive CCL

**H1d:** The synchronous software training method results in a positive CCL.

| | | **Instructor Teaching** | |
|---|---|---|---|
| | | **Without Computers** | **With Computers** |
| **Students' Learning** | **CONCURRENTLY WITHOUT Computers** | ***TRADITIONAL*** *Traditional Instruction, Delayed Practice* | ***DELAYED*** *Computer-based Instruction, Delayed Practice* |
| | **Concurrently With Computers** | ***ASYNCHRONOUS*** *Traditional Instruction, Concurrent Practice* | ***SYNCHRONOUS*** *Computer-based Instruction, Concurrent Practice* |

**Figure 2: A Classification Framework for Computer Software Training in a Group Setting**

**H2:** There is a difference in CCL depending on whether or not the students have access to computers during classroom instruction.

**H3:** There is a difference in CCL depending on whether or not the instructor has access to computers during classroom instruction.

**H4:** There is a difference in student satisfaction (SAT) depending on whether or not the students have access to computers during classroom instruction.

**H5:** There is a difference in student satisfaction (SAT) depending on whether or not the instructor has access to computers during classroom instruction.

All hypotheses have been stated in the alternate form. The direction of difference has not been specified in hypotheses 2 though 4. While the popular literature would suggest that there are more benefits from computer-based education, our literature review only found mixed evidence. Therefore, we refrained from making directional hypotheses.

## 4. RESEARCH METHODOLOGY

An exploratory experimental methodology using student subjects was employed for exploration of the research hypotheses. The experimental methodology was chosen as it provides greater control and leads to greater internal validity of the results (Cooper & Schindler 2002). The institutional review board of one author's institution approved the use of the proposed protocol to collect data from undergraduate students to evaluate the effectiveness of alternative software training methods.

### 4.1 Pre-Treatment

The participants signed a "consent statement" and provided demographic and background data about themselves. Next, they took a computing literacy (i.e., skills) test. This test required developing an Excel worksheet with tasks like adjusting heights of rows and widths of columns, entering text and numbers, entering simple formulas and functions (Sum, Average, Min, Max), using different font types and font styles, and copying cell entries. Students were allowed 25 minutes to work on this test. The maximum score on the test was 100. These are explicit and non-latent measures; so no statistical tests for reliability and validity were necessary. Moreover these tests were developed over several years and thus had face validity. Similar tests were given in earlier exams by two instructors and were found to provide an adequate measure of students' computing literacy. The scores generally had a normal distribution and the students found the questions to be neither too hard nor too easy.

### 4.2 Treatment

One week after the pre-treatment session, each of the four training methods was administered to one of the four sections (i.e., the experimental groups) of a required computer literacy course. The assignment of treatments to the four experimental groups was done at random. The same instructor taught using the four training methods to control variability due to instructor differences. All training sessions were held in the same classroom to control for possible variability due to differences in classroom layouts.

The task was to teach entering text and numbers, entering formulas and functions (Sum, Average, Min, Max) including copying of cell entries. The task also included improving the looks of the worksheet by adjusting column widths and row heights, centering worksheet title over a range of columns, formatting numbers in different ways, using different color schemes, and checking spelling. Finally, the task required the students to create a 3-D bar chart, improve the looks of the chart, do some housekeeping like naming the worksheet and bar charts and save their work. The task duration was controlled at 75 minutes.

The equipment was thoroughly checked before the start of each treatment. For each treatment, the subjects received a handout clearly listing the sequence of steps to go through. The handout provided adequate space to take notes. The instructor always made himself available to answer students' questions. Students were encouraged to take notes and ask any questions during the presentation. Details of each training method are narrated below.

**4.2.1 Traditional:** The instructor went through the entire Excel Project demonstrating every step using traditional method -- chalkboard and overhead projector. Forty five minutes were allowed for this presentation. Once the presentation was over, the students immediately practiced the entire lesson themselves for 30 minutes.

**4.2.2 Delayed:** The instructor went through the entire Excel Project demonstrating every step on the computer for the students to watch. Forty five minutes were allowed for this instruction. Immediately afterwards, students practiced the entire lesson themselves for 30 minutes.

**4.2.3 Asynchronous:** The instructor went through the entire Excel Project demonstrating every step using traditional method -- chalkboard and overhead projector. The students went through the steps concurrently with the instructor presentation.

**4.2.4 Synchronous:** The instructor went through the entire Excel Project demonstrating every step on the computer for the students to watch. The students went through the steps concurrently with the instructor demonstration.

### 4.3 Post-Treatment

Immediately following the treatment, each participant filled an instrument to measure the level of satisfaction with the training method. This instrument contains thirteen questions pertaining to satisfaction. A seven-point semantic differential scale similar to the validated instruments by Bailey and Pearson (1983) and Ives et al (1983) was used for these questions. Finally, each student took the same computing literacy test that was taken at the pre-treatment stage. The time allowed for this test was 25 minutes.

Data was analyzed for only those subjects who were present at both the pre-treatment and post-treatment tests. Therefore, twelve incomplete observations were dropped. Also, observations with pre-treatment computing literacy scores of more than 90 were dropped from the analysis, as these students had very little to gain from any of the four training methods. Eight such observations were dropped.

This left us with a total of 34 usable observations. The final counts were: 10 observations each for the traditional and synchronous methods and 7 observations each for the delayed and asynchronous methods. We checked for the adequacy of **sample sizes.** Using the procedure described by Neter and Wasserman (1974), using $\alpha = 0.05$ and $\beta = 0.10$, and making other justifiable assumptions, the recommended sample size for each treatment was 8. Thus our sample sizes are reasonable with a power of the test being 0.90.

## 5. ANALYSIS AND RESULTS

### 5.1 Participant Profile

While the participants were students, they are more representative of more mature and experienced users. They were mostly commuter students with average full time experience of 4.34 years in industry and were working on an average of more than 30 hours per week. The average full time experience of the four groups ranged from 3.56 to 5.2 years. The average age for the four groups ranged from 20.8 to 23.0. Except for the delayed method, where all participants were males, the male ratio was between 50% and 60%. About two thirds of the participants were juniors. We also asked the participants to indicate their perceived level of proficiency in various office software products to ensure that they would benefit from software training. While the self-perceived proficiency can be deceptively high, the scores ranged from low to medium indicating the need for and usefulness of software training.

### 5.2 Hypothesis Testing

*H1: Each training method results in a change in computing literacy (CCL). The four sub-hypotheses are:*

*H1a: The traditional software training method results in a positive CCL.*

*H1b: The delayed software training method results in a positive CCL.*

*H1c: The asynchronous software training method results in a positive CCL.*

*H1d: The synchronous software training method results in a positive CCL.*

Table 1 provides descriptive statistics for the pre-treatment scores, post-treatment scores, and the improvement. A paired t-test was conducted to test the positive improvement hypothesis for each of the four samples. As the p values show in the table, all improvement scores are significant. Thus H1 is fully supported. While fully expected, the support for the hypothesis lends credibility to all training methods and allows us to explore the differences between the training methods.

*H2: There is a difference in CCL depending on whether or not the students have access to computers during classroom instruction.*

*H3: There is a difference in CCL depending on whether or not the instructor has access to computers during classroom instruction.*

In order to test these two hypotheses, the improvement in computing literacy (CCL) score was computed for each participant. The summary statistics for CCL are shown in Table 1. The CCL scores became the raw data for further analysis. The two hypotheses can be evaluated either by using the two factor analysis of variance (ANOVA) or multiple regression with indicator variables, providing equivalent results. We used the multiple regression method as it allows for a simpler treatment of the interaction effect. Accordingly, the regression model being tested is:

$$CCL = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2 + \xi$$

Where,

$X_1$ is an indicator variable referring to the subject having a computer
= 1, if the subject has a computer for concurrent practice,
= 0, otherwise,

$X_2$ is an indicator variable referring to the instructor having a computer
= 1, if instructor has a computer,
= 0, otherwise,

$X_1X_2$ is the interaction term,

$\xi$ is the error term, and

$\beta_0$, $\beta_1$, $\beta_2$, and $\beta_3$ are the regression coefficients.

| Statistic | Traditional Method | Delayed Method | Asynchronous Method | Synchronous Method |
|---|---|---|---|---|
| **Mean of Pre-Treatment Scores** | 49.6 | 53.0 | 48.9 | 33.6 |
| **Standard Deviation of Pre-Treatment Scores** | 23.56 | 18.1 | 23.27 | 17.2 |
| **Mean of Post-Treatment Score** | 87.4 | 86.9 | 90.7 | 80.2 |
| **Standard Deviation of Post-Treatment Scores** | 15.1 | 12.46 | 10.97 | 21.0 |
| **Mean Improvement** | 37.8 | 33.9 | 41.9 | 46.6 |
| **Standard Deviation of Improvement** | 23.2 | 22.0 | 23.68 | 28.46 |
| **Paired t test for Improvement: p value** | 0.00301 | 0.0031 | 0.0017 | 0.0017 |

**Table 1: Summary of Computing Literacy Scores**

We first evaluated the interaction effect between the independent variables $X_1$ and $X_2$. $\beta_3$ is the coefficient for the interaction effect. Using the t-test, $\beta_3$ was found to be insignificant ($p = 0.619$). Thus we are not able to identify any effect on computing literacy because of the interaction between the students having computers and the instructor having one. As a result, the interaction term was dropped from the model resulting in:

$$CCL = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \xi$$

**Hypothesis 2** can be examined by testing for $\beta_1$. The value of the estimator $b_1$ for $\beta_1$ is .177 and the corresponding p value is 0.332. Thus H2 is not supported, and we have no evidence that students having computers in the classroom improves their computing literacy.

**Hypothesis 3** can be examined by testing for $\beta_2$. The value of the estimator $b_2$ for $\beta_2$ is 0.008 and the corresponding p value is 0.963. Once again H3 is not supported, and we have no evidence that the instructor having a computer in the classroom improves the students' computing literacy.

*H4: There is a difference in student satisfaction (SAT) depending on whether or not the students have access to computers during classroom instruction.*

*H5: There is a difference in student satisfaction (SAT) depending on whether or not the instructor has access to computers during classroom instruction.*

Again, we used multiple regression with indicator variables to test these two hypotheses. In order to investigate the interaction effect as well, the regression model being tested is:

$$SAT = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2 + \xi$$

where the variable definitions are the same as before.

The interaction effect is evaluated by looking at $b_3$, the estimator for $\beta_3$. It is - 1.289 and the corresponding p value is 0.073. Although not statistically significant at the .05 level, there seems to be some effect on satisfaction due to the interaction between the students having or not having computers and the instructor having or not having computer during the learning process. Figure 3 depicts this interaction effect. While the satisfaction lines do not intersect in the figure, they come pretty close. The lines suggest that the impact on student satisfaction with the student having a computer (versus not having access) is greater than when the professor has access to computer (versus not having access).

In any case, since the p value is greater than .05, we drop the interaction term leading to the simplified model:

$$SAT = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \xi$$

**Hypothesis 4** can be examined by testing for $\beta_1$. The value of the estimator $b_1$ for $\beta_1$ is .0.454 and the corresponding p value is 0.003. Thus H4 is supported. Thus we conclude that the student satisfaction level is significantly higher if they have access to computers in the classroom.

**Hypothesis 5** is examined by testing for $\beta_2$. The value of the estimator $b_2$ for $\beta_2$ is 0.362 and the corresponding p value is 0.016. Thus H5 is also supported. In other words, the student satisfaction level is significantly higher if the instructor uses a computer in the classroom to demonstrate the lesson.

## 6. DISCUSSION

Our first hypothesis was supported indicating that all methods of software training, whether computer supported or not, led to an improvement in the computing skills of the research participants. While expected and not surprising, this result validates the need for continued software training and the need to find alternative ways to improve training methods based on newer instructional technologies.

### 6.1 Impact on Performance Outcomes

The next two hypotheses regarding improvement in computing skills based on the four training methods (and the two factors) were not supported. It did not matter whether the instructor used a computer while lecturing or the students practiced on computers during the lecture session; performance was not affected. We were not totally surprised as recent research has shown many cases of lack of improvement in student performance (Rankin & Hoass 2001; Young et al. 2003; Benbunan-Fich 1999; McLaren 2004). This may be disappointing news to purveyors and champions of modern instructional technology in the classroom. While we cannot make a generalization, we cannot also make a blanket endorsement of the indiscriminate use of computer technology in the classroom. University administrators and decision makers must carefully evaluate the benefits and costs associated with the use of technology before making significant resource commitments.

Obviously, this is a paradox similar to the productivity paradox of yesteryears (Brynjolfsson 1993), related to the use of computers and information technologies in business. While many of the isolated studies do not report improvement in student performance, the use of computer technology in the classroom is generally on the rise. How can we explain the contradiction? One way to explain these results is by way of examining the evaluation framework presented in Figure 1. While we controlled for task and subject in our experiments, the differential effect of computer-based training may be contingent on the nature of the task and the subject profile. Task type and complexity may affect outcomes. While significant performance improvements were not observed in Economics (Rankins and Hoaas 2001), Marketing (Young et al. 2003), and Statistics (Cybinski & Selvanathan 2005), we expected to see the most improvement in software training, which itself is in the domain of computers. It is possible that our tasks were relatively simple and straightforward; more complex tasks may benefit from computer-based training. Bolt, Killough and Koh (2001) gave their subjects one of two tasks, which differed in the number of constraints included in a linear programming problem – both tasks required the use of Solver in Excel. Kolb (1984) argues that because of the experiential nature of learning, different learning situations are necessarily different experiences. Kolb's learning styles model and experiential learning theory are today acknowl-

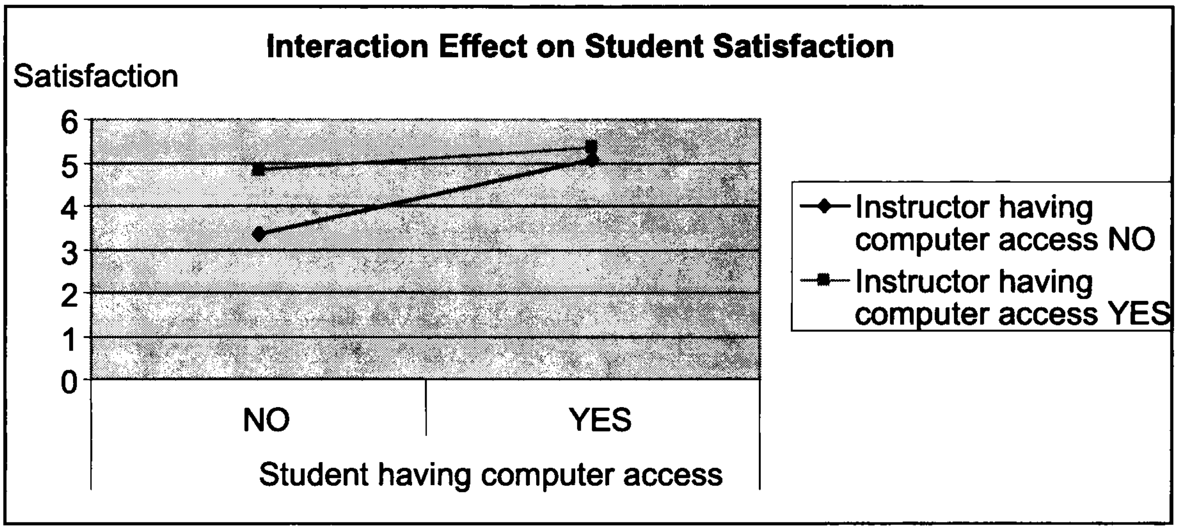


**Figure 3: Interaction Effect on Student Satisfaction**

edged by academics, teachers, managers and trainers as truly seminal works. A subject may, therefore, prefer one learning style (training method) in one situation (task) and a different style in another situation. Task structure may be another factor to consider. For example, Glasbeek (2004) contrasted two types of spreadsheet exercises: problem-solving exercises with a well-defined goal, and on-your-own exercises. In their experiments, open-task instruction + problem-solving exercises and specified task instruction + on-your-own exercises performed better than other scenarios.

While our subjects did not experience the benefits of computer-based training, the attributes of the subjects need further examination. Our subjects had limited work experience. Subjects with more experience, and those in industry and work-settings may experience different results. Mason (1989) has clearly articulated differences between subjects in laboratory and field settings. Other dimensions on which subjects differ are their cognitive style and personality type. The Jungian problem-style as operationalized by the Myers-Briggs Type Indicator (MBTI) (Myers 1975) has four scales. The two scales most commonly used in IS research are thinking-feeling and sensing-intuition and may be the appropriate ones to use in computer-based education research. Recently, Schniederjans (2005) found that four personality characteristics are highly correlated to student achievement in Web-based courses. In the same vein, Glasbeek (2004) found different results for learners with ill-defined goal vs. the ones with better-defined goals. The implication is that while aggregate results may not show significant results, specific types of users may benefit more than others from computer-based training.

In this research, we considered only one level of performance outcome, i.e., computing literacy and found no significant differences between the four training methods. In spreadsheet software training, perhaps this is more appropriate to measure than others. However, the well known six cognitive learning objectives articulated by the famous Bloom's taxonomy (Bloom 1984), may be relevant in the context of computer-based training. The six objectives arranged in hierarchically ascending order are:

a. *Knowledge*: learners have knowledge of and ability to recall or recognize information.
b. *Comprehension*: learners understand and can explain the knowledge in their own words.
c. *Application*: learners are able to use knowledge in real situations.
d. *Analysis*: learners are able to break down complex concepts or information into simpler, related parts.
e. *Synthesis*: learners are able to combine elements to form a new, original entity.
f. *Evaluation*: learners are able to make judgments.

Computing literacy, as we measured, corresponds to the *Application* category in Bloom's taxonomy. The widely used measure known as "computer literacy" can be likened to the *Knowledge* and *Comprehension* categories, while the last three categories require critical thinking skills on part of the subjects.

Past research has generally addressed the lower categories in the Bloom's taxonomy; relatively little effort has been made at multiple and higher levels, partly because the higher levels are difficulty to operationalize and measure. Some examples of measuring multiple levels of learning outcomes are by Webb, et al. (2005), Young et al. (2003), and Wang (2002). Again, it may be that different learning outcomes may necessitate different learning strategies. In addition, while we and others have examined short-term benefits of instructional technologies, the long-term impacts of computer-based methods on learning outcomes may exhibit quite different patterns.

In essence, there are two ways to explain our performance outcome results. The most apparent and the obvious one is that technology's influence is minimal or secondary (Young et al. 2003). However, we maintain that the effectiveness of different computer-based training methods is a more complex phenomenon. We are more prone to agree with Webb et al. (2005) in pointing out that the model of learning and its fit with supporting technologies, rather than the presence of technology per se, enhances learning outcomes.

### 6.2 Impact on Affective Outcomes

The students' satisfaction level is improved when they are able to use computers in the classroom. They are also more satisfied when the instructor uses the computer during the lecture to demonstrate the software. Thus both hypotheses four and five are supported. While not statistically significant at the 5% level, there is some interaction between the students using the computer and the instructor using the computer. It appears that there is more satisfaction if the students use the computers than when the instructor uses the computer.

These findings are certainly consistent with many previous studies where the student satisfaction and perceptual measures show an improvement with computer-based education in the classroom. Improved satisfaction was reported by Arbaugh (2000) in Internet-based courses, and perceived usefulness and perceived flexibility were among the determinants of satisfaction. In the experiment conducted by Benbunan-Fich (1999), better perceptions of learning resulted from the interaction of teamwork and asynchronous computer-support. On the other hand, Cybinski and Selvanathan (2005) found that the group studying Statistics in technology-supported environment experienced more assessment anxiety on one hand and more enjoyment of the subject on the other hand.

How do we assess the seemingly contradictory results between performance and satisfaction? One way is to look at the internal psychological processes through which learning occurs. According to Alavi and Leidner (2001), these processes include cognitive and information processing activities, motivation, interest, and cognitive structures. We content that when these processes are facilitated, satisfaction and other perceptual measures would show a marked improvement. While the performance measures may not show an immediate statistically significant improvement due to the various reasons postulated above (i.e., nature of task, subject characteristics, and short duration of the study), satisfaction measures are likely to be more immediately influenced.

The positive impact on affective measures may have another positive outcome. Researchers have shown a linkage between satisfaction and continued use of technology. In their cognitive model, Oliver (1980) showed a relationship between satisfaction and intention for continued use, mediated by attitude. More recently, Bhattacherjee (2001) validated a direct linkage between satisfaction and continued intention to use technology. Simply stated, satisfied users are more likely to continue to use the technology. According to this premise, subjects who are more satisfied are more likely to use the software for the long run, ultimately resulting in more performance improvements. Their current performance may not be necessarily a motivating factor for the continued use of the software.

### 6.3 Limitations

Our results and their implications need to be viewed in light of the research methodology and the procedures employed. The laboratory experiments provide high internal validity, but at the same time limit generalizability because of the use of various controls. Among controls were: student subjects (although they were more representative of a more mature and working population), a task of simple to medium complexity, and the same instructor using the four training methods. While the sample sizes for the four treatments were adequate for an exploratory study, we may be able to detect finer differences with larger sample sizes. Also, more performance outcomes and affective outcomes need to be evaluated to gain better insights into computer-based training methods.

### 6.4 Implications for Practice

While we have included implications for research in the above discussion, we have a few recommendations for practice also. Most importantly, based on the findings, academic institutions and corporations need to be careful when investing in instructional technologies and computer classrooms, since we did not find evidence of higher returns in terms of improved performance by the students. We did find that the students were more satisfied with software training when they had concurrent practice on the computers. If one takes the view that students are "customers", then institutions certainly need to keep them happy and satisfied. Furthermore, because of competitive pressures on educational institutions, it may be trendy and popular to equip classrooms with computers. Based on performance alone, however, our study does not support such expense. The jury may still be out as this is only one study with its own limitations and there may be tasks and circumstances where concurrent computer interaction will in fact be useful. In any case, we encourage organizations not to jump on the band wagon, and make this resource acquisition decision based on several factors including cost, improved performance, internal strategy, long-term effects, and competitive pressures.

## 7. CONCLUSION

In summary, our results indicate that while affective measures (i.e., satisfaction) improve with computer-based education, the actual performance outcomes (i.e., computing literacy) do not. Regarding the effectiveness of computers in the classroom, a simple-minded analysis would seem to indicate that improvement in performance due to instructional technology is indeed a <u>myth</u>, not borne out by reality and research measurements.

However, we confirm <u>truth</u> in reporting improvement in affective outcomes reported by our research participants. There are complex psychological processes at work during learning and at least some of them may have been positively affected to cause an improvement in satisfaction. We contend that the positive effect of these processes have a bearing on the long-term effects of computer based education.

Based on our discussion emanating from the research model, there is definitely <u>more</u> to computer-based education, which we hope should be able to answer this apparent paradox. Further research is needed to learn about the deep psychological processes of learning, how they are affected, and their long-term effects. We also encourage researchers to use the evaluation framework proposed in this article to get a firmer grip on when, how, and why computer-based methods can lead to improvement in education. As described in the discussion section earlier, various combinations of task, subject, learning outcomes, training methods, affective measures, and performance measures need to be explored to gain a fuller understanding. In fact, the framework itself may serve as the basis for a sustained program of research in computer-based education.

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