A Comparison of the Usability of Notebook and Desktop Computers at the United States Air Force Academy

Major Marie A. Revak
Center for Educational Excellence

Margaret (Peg) Halloran, Ph.D.
Institute for Information Technology Applications

James C. Miller, Ph.D.
Human-Environmental Research Center

October 2001
(revised)

ABOUT THE AUTHORS:

MARIE REVAK

Major Marie Revak is the Director of Academic Assessment and an Assistant Professor of Mathematics at the US Air Force Academy. Her areas of interest include testing and assessment, mathematics education, faculty development, technology integration and calculus and statistics reform. She has served as a Space Operations Officer and received a Ph.D. in Mathematics Education from the Florida Institute of Technology.

MARGARET (PEG) HALLORAN

Peg Halloran received a Ph.D. in Behavioral Ecology from the University of Colorado, Boulder in 1993. In August of 1998, she became the Director of Educational Technology for the Institute of Information Technology Applications. Her research efforts include a user-centered and designed portal system for the United States Air Force Academy (USAFA), the pedagogical uses of E-books and hand held computing devices. In addition to her research on the educational applications of information technology, Dr. Halloran continues to teach Ecology and Animal Behavior courses in the Biology department at USAFA.

JAMES C. MILLER

Dr. James C. Miller was Director of the Human-Environmental Research Center at the United States Air Force Academy. Currently he is Research Director of the Warfighter Fatigue Countermeasures Group (HEPM) at the Air Force Research Laboratory at Brooks AFB. There, he is involved in basic, exploratory, and advanced research to provide a competitive advantage to military and aerospace crews and weapons systems operators. He holds a Ph.D. (Biology) from the University of California, Santa Barbara, and a B.A (Biology), and is a Certified Professional Ergonomist (CPE).

TABLE OF CONTENTS

ACKNOWLEDGEMENTS

ABSTRACT

The purpose of this study was to assess the effect of portable computers on the USAFA faculty's ability to contribute to teaching, research, and service. The objectives of the study were to determine (1) the criteria under which notebook computers were feasible alternatives to desktop computers; (2) which features of notebook and desktop computers faculty used; (3) which software products faculty used on notebook and desktop computers; (4) the criteria under which a similar investigation should be conducted with cadets; and (5) a research basis to facilitate the identification of potential applications of notebook computers for the Air Force and Department of Defense.

The sample consisted of 93 faculty members (experimental n = 54, control n = 39). Faculty members in the experimental group turned in their desktop computers for notebook computers. Faculty in the control group received new desktop computers, changing their operating system simultaneously. The groups were found to be demographically similar.

A series of five surveys were used to collect data over the eleven-month period of the study. The initial survey provided baseline data; three periodic surveys and an exit survey tracked the faculty through the course of the study; and the exit survey provided additional data as the study came to a close. Both quantitative and qualitative data were collected and analyzed.

Major findings of the study are reported by computer type. The notebook computer group: (1) reported higher satisfaction with their overall computer experience, computer speed, response time, and ergonomic design; (2) provided a higher proportion of positive comments on the surveys; (3) spent more time (per person) dialing in; (4) took their computers home an average of 2-3 times per week; (5) used their notebook computers 93% of the time; (6) reported more required repairs; (7) added more hardware and software; and (8) suffered no losses due to theft or accidents. The desktop computer group used their desktop computers 80-85% of the time, relying more on other computers. Both groups reported a similar proportion of ergonomic problems and used computers in teaching about one-third of the time. The biggest reported

positives for notebook computers were work ubiquity and increased productivity. The biggest reported negatives were the mouse and keyboard.

As a result of this research, notebook computers were seen as a valuable addition to the computing "mix" at the Air Force Academy and a decision was made to conduct a small pilot study with cadets during the year 2000.

A Comparison of the Usability of Notebook and Desktop Computers at the United States Air Force Academy

INTRODUCTION

The US Air Force Academy has been considering the option of issuing portable laptop and notebook computers to cadets in place of desktop computers for several years. The US Military Academy (USMA), West Point NY, conducted a small pilot study of notebook computers in 1994. Eighteen USMA cadets (one classroom group) were given notebook computers for the entire spring semester. The notebook computer was chosen to match the capabilities of the cadet desktop model. Due to the high failure rate and high cost of the notebook computers (when compared to desktops), the researchers concluded that notebook computers were not yet acceptable replacements for desktops.

Mayville State University (MSU) and Valley City State University (VCSU) in North Dakota adopted notebook computers for all students and faculty in 1996. They reported overwhelmingly favorable results including increased level of communication on campus, improved student retention rates, increased instructor use of technology, improved research abilities, and improved ability for students to work in groups. When considering these results, we noted that the MSC/VCSU study confounded the effects of issuing computers to all students with the effects of notebook computers, themselves.

Most researchers agreed on the advantages of notebook computers, citing the opportunity to bring computers to class, the ability to bring computers on athletic and other trips, ease of storing computers, ease of transporting a failed computer for repair, equal access to computers across disciplines, increased number of content delivery options, and the ability to create a lab environment in any classroom.

Researchers also tended to agree on the disadvantages of notebook computers. The West Point researchers were disturbed by the failure rate among notebook computers (31 percent of the computers failed during the study). Other disadvantages included the 12 to 18 month "technology gap" for notebooks, lack of upgrade capability, short battery life, increased repair costs, and ergonomic problems associated with the small screen and small keyboard.

Since the West Point study, notebook computers had become less expensive, more powerful and more durable. In 1998, a listing of "Notebook Colleges and Universities" included over 50 institutions. More campuses added notebook computers for faculty and students as we conducted our study and in July of 2000, the number of notebook campuses had doubled to over 100[1]. Late 1998 was seen as the right time for the US Air Force Academy (USAFA) to conduct its own investigation to assess the feasibility of notebook computers as replacements for desktop computers. Fiscal Year 98 fallout money provided funding for 100 Pentium II notebook computers for faculty.

This investigation was planned as the first in a series of multi-disciplinary studies designed to assess alternatives to traditional desktop computers. Specifically, the plan was to assess the effect of portable computers on the faculty's ability to contribute to teaching, research, and service. The objectives of the study were to determine:

- The criteria under which notebook computers were feasible alternatives to desktop computers.
- How notebook computers affected the faculty's teaching, research, and service.
- Which features of notebook and desktop computers faculty used.
- Which software products faculty used on notebook and desktop computers.
- The criteria under which a similar investigation should be conducted with cadets.
- A research basis to facilitate the identification of potential applications of notebook computers for the Air Force and Department of Defense.

METHODS

Experimental Design. The investigation used a mixed design. The experimental group consisted of faculty members who volunteered to turn in their desktop computers for notebook computers. Both the desktop computers (turn-ins) and their replacement notebook computers used the Windows98 operating system. The control group consisted of faculty members who requested and received new, replacement Pentium II desktop computers with a different operating system than they had been using (Windows NT replaced Windows 98). A series of six surveys were scheduled for on-line administration throughout one calendar year (November 1998 – December 1999) to collect longitudinal data on hardware and software use, ease of use, and frequency of use within the experimental and control groups.

Various tests of statistical significance were used to examine intergroup and repeated measures differences. Statistical significance was accepted at a level of 95% ($p<.05$). The use of the word "significant" in the text of this report refers to statistical significance.

Subjects. Members of the notebook group (experimental group) were a subset of over 100 faculty volunteers who gave up their desktop computers in exchange for notebook computers. Since there were more volunteers than computers, the investigators selected those who were teaching during the current semester with more than one year of their USAFA tour remaining. The desktop group (control group) was a subset of 150 faculty members who received new desktop computers.[2]

Procedures. The Entry Survey was taken by notebook group participants shortly before their notebook computers were issued, and by desktop group participants shortly after their new desktop computers were issued. The Periodic Survey was to be given six times, with a specification each time about the computer and the period that was to be rated:

1. In conjunction with the Entry Survey. The survey applied to the participant's experience with his or her older USAFA desktop computer during the preceding three months
2. Mid-spring semester 1999. The survey was to apply to the participant's experience with his or her new USAFA computer during the first half of the spring semester
3. End of the spring semester 1999. The survey was to apply to the participant's experience with his or her new USAFA computer during the second half of the spring semester
4. End of the summer 1999. The survey was to apply to the participant's experience with his or her new USAFA computer during the summer
5. Mid-fall semester 1999. The survey was to apply to the participant's experience with his or her new USAFA computer during the first half of the fall semester
6. End of the fall semester 1999. The survey was to apply to the participant's experience with his or her new USAFA computer during the second half of the fall semester

Based upon an analysis of data from Periodic Surveys 1 through 4, the decision was made to drop Periodic Survey 5. The Exit Survey was to be given in conjunction with the last Periodic Survey. The Surveys are shown as attachments to this report. The surveys were implemented in hypertext markup language (HTML) and common gateway interface (CGI) on a personal web server connected to the USAFA Intranet. The data were stored automatically in comma-delimited ASCII text files and imported into spreadsheet software for data reduction.

Where practical, the comments of all participants were summarized by type of computer, Academic Division, and affect (positive or negative). The use of all data, though unbalanced in number across survey periods, provided a large enough sample size within each Division to allow a meaningful summary of data by using the following categories:

- Total number of respondents and number of respondents by Academic Division
- Total number of comments and number of comments by Academic Division
- Number of positive comments
- Number of negative comments
- Specific comments of interest

Satisfaction ratings. The subjective rating scales in the surveys were constructed with reference to Babbitt and Nystrom (1989) to help ensure that respondents would differentiate among scale anchors. For "satisfaction," the users provided six subjective ratings on a scale of 1 (very unsatisfactory) to 6 (very satisfactory), with only those two anchor phrases on the scale.

RESULTS

Subject Demographics[3]

The entry survey included several questions pertaining to group demographics. As of 8 January 1999, 86 Notebook users and 48 Desktop users had responded to the Entry Survey. Analysis of demographic data showed that the two groups did not differ with respect to age, military-civilian mix, gender, academic degree, academic rank, computer experience, personal computer experience, previous experience with notebook computers, experience using e-mail, experience with the USAFA intranet, experience with the world wide web, experience with the USAFA dial-in service, and experience with other providers' dial-in services. Comparisons between academic divisions revealed an apparent tendency for faculty in the engineering division to select the desktop configuration over the notebook configuration (Figure 1). Ninety-three of the original participants remained at the end of the study (Periodic Survey 4). The two groups did not differ substantially from each other and resembled closely the original pool of participants.
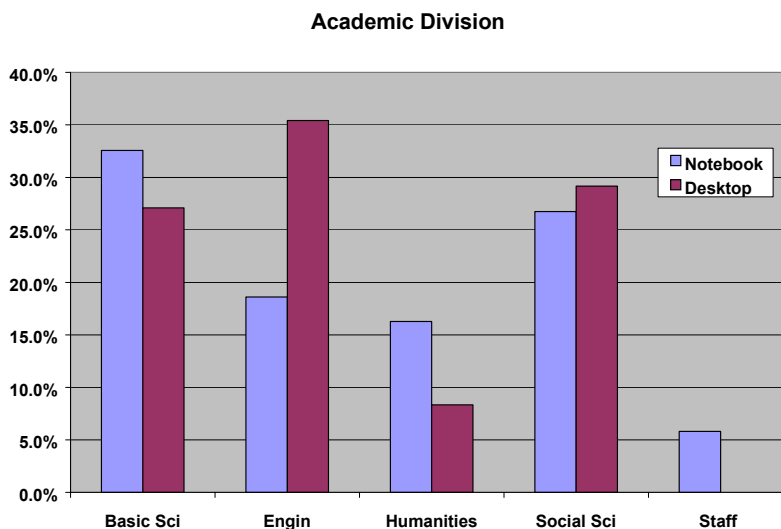
Academic Division

Figure 1 Distribution of computers across academic divisions.

In addition to collecting demographic data, the entry survey assessed six dimensions of satisfaction including "personal computers," "laptop/notebook computers," "Internet e-mail," "USAFA Intranet," "web browsing" and "the USAFA dial-in service" using a scale of 1 (very unsatisfactory) to 6 (very satisfactory), with only those two anchor phrases on the scale (Figure 2). The groups did not differ significantly on any of these dimensions except for their ratings of the USAFA Intranet, which received higher ratings from the notebook computer group.
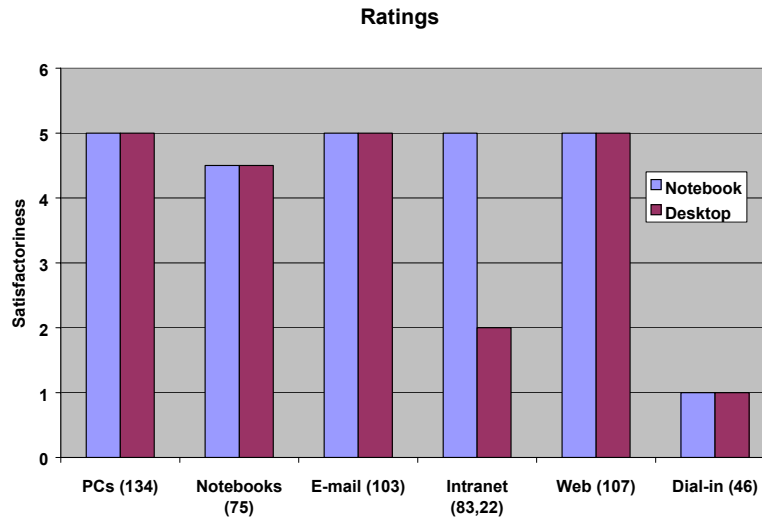
Ratings

Figure 2 Subjective ratings of satisfactoriness (6 is high) for personal computers, notebook computers, e-mail, the USAFA Intranet, the World Wide Web, and the USAFA dial-in service. Figures in parentheses are sample size. The ratings for the Intranet differed between groups (see text).

Sample

A total of 152 participants completed the Entry Survey, including 87 from the experimental group (notebook users) and 65 from the control group (desktop users). Of the 152 initial participants, survey completion dropped as the study progressed. The missing data were not replaced. These survey response sample sizes are summarized in Table 1 and Figure 3. The 93 participants who responded to Periodic Survey 4 were used for all data summaries and analyses that follow, except for participant comments. All participant comments were used.

TABLE 1 Numbers of participants completing and missing surveys.

Group	Completed Entry	Completed Periodic 4	Missed Periodic 1	Missed Periodic 2	Missed Periodic 3
Notebook	87	54	0	1	6
Desktop	65	39	2	1	3
Total	152	93	2	2	9

5
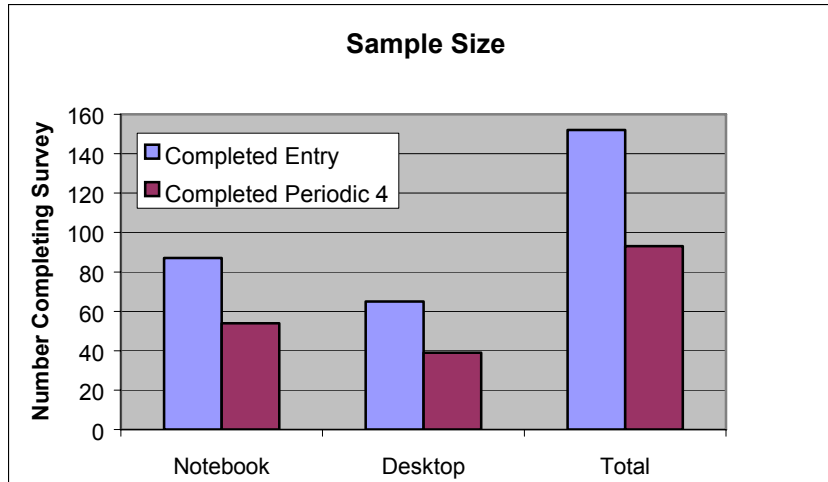
Figure 3 Sample size for both groups diminished as the study progressed. The 93 subjects who completed all surveys were used for all subsequent analyses.

Periodic Survey Results

Application Software Satisfaction. The subjective ratings for satisfaction with relatively common application software were analyzed for differences between the groups. All median ratings were at the level of 3 or better on the rating scale that ranged from 1 through 6, where 1 was "Very Unsatisfactory" and 6 was "Very Satisfactory." There were six inter-group differences that exceeded 1 scale unit and, thus, were of interest:

- Notebook users' satisfaction with FrontPage, a web-site design tool, was higher than it was for desktop computers in Periodic Surveys 1, 2 and 3. This difference disappeared in Periodic Survey 4.
- Similarly, notebook users' satisfaction with Composer, another web-site design tool, was higher than it was for desktop computers in Periodic Survey 2. This difference did not appear in the other three Periodic Surveys.
- Finally, desktop users' satisfaction with the USAFA Grader software in Periodic Surveys 2 and 3 was higher than it was for notebook users. This difference disappeared in Periodic Survey 4. The two median ratings of 3 for the notebook users' satisfaction with Grader were the lowest median ratings reported.

Other than the differences described above, there were no remarkable changes in subjective ratings across the four Periodic Surveys. However, when all of the medians of the satisfaction ratings were combined as n-weighted means, it was obvious that, after the new computers were received, the notebook group provided slightly higher overall ratings of satisfaction with their computers than the desktop users group (Periodic Surveys 2, 3 and 4, see Figure 4).

6
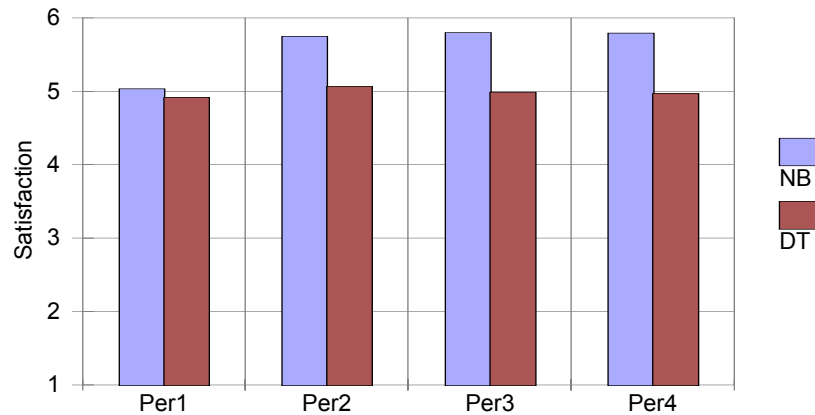
Figure 4 Overall application software satisfaction: n-weighted means of the medians reported in the periodic surveys. NB = notebook computer; DT = desktop computer; Per = Periodic Survey.

Frequency of Use. The perceived frequency of CD-ROM use, Ethernet access and modem use on the 7-point scale, where 1 = Never, 4 = Sometimes, and 7 = Always, is shown in Table 2. Generally, the CD-ROM was used "Sometimes" and Ethernet access was used "Always" by both groups across all periods. Modem use was in the "Never" range for both groups before the study notebook computers were received (during the time period reported in Periodic Survey 1). Subsequently, modem use for the notebook user group increased to the "Sometimes" range and remained there, while it continued at the "Never" level for the desktop user group.

TABLE 2 Median scores and differences for subjective ratings on a 7-point scale for perceived frequency of CD-ROM use, Ethernet access and modem use. Differences greater than 1 scale unit are marked in bold type.

	CD-ROM	Ethernet	Modem
Period 1			
Notebook median	4.5	6	1
Desktop median	4	7	1
difference	*0.5*	*-1*	*0*
Period 2			
Notebook median	4	7	4
Desktop median	4	7	1
difference	*0*	*0*	***3***
Period 3			
Notebook median	4	7	4
Desktop median	4	7	1
difference	*0*	*0*	***3***
Period 4			
Notebook median	4	7	4
Desktop median	5	7	1
difference	*-1*	*0*	***3***

Additional Hardware and Software. The number of users making actual reports of hardware and software additions to the basic systems is shown in Table 3. The number of additions rose after Periodic Survey 1, when new computers were introduced. Also, note that the numbers of hardware and software additions to the notebook computers always exceeded the numbers of additions to the desktop computers.

TABLE 3 **The numbers of users making actual reports of hardware and software additions to the basic systems.**

	Additional Hardware	Additional Software
Period 1		
Notebook median	18	20
Desktop median	11	17
difference	*7*	*3*
Period 2		
Notebook median	25	23
Desktop median	14	22
difference	*11*	*1*
Period 3		
Notebook median	27	22
Desktop median	11	14
difference	*16*	*8*
Period 4		
Notebook median	29	24
Desktop median	11	11
difference	*18*	*13*

For the notebook computer group, the uses of external keyboard, mice and monitors were reported more than any other installed hardware devices.

Computer Use. The estimates of the proportion of time for all computer use are shown in Table 4. Prior to the availability of the study notebook computers (Periodic Survey 1), the use of desktop computers was much more prevalent for both user groups. After the study notebooks became available (Periodic Surveys 2, 3 and 4), the relative amounts of time spent with each type of computer aligned with the user group and remained relatively constant across measurement periods. Across the latter three periods, the notebook user group used their study notebook computers about 93% of the time that they used a notebook, while the desktop user group used their study desktops about 80-85% of the time they used a desktop.

TABLE 4 The percentages of time faculty spent using different types of computers. Note: Columns for "Any Laptop or Notebook" and "Any Desktop" should total to approximately 100%. The "Study Notebook" and "Study Desktop" columns represent the proportion of time for the new computers issued for the study.

	Any Laptop or Notebook	Study Notebook	Any Desktop	Study Desktop
Period 1				
Notebook mean	16.9	N/A	81.3	N/A
Desktop mean	3.8	N/A	93.5	N/A
Period 2				
Notebook mean	89.3	93.1	10.9	2.0
Desktop mean	6.3	4.6	93.2	85.0
Period 3				
Notebook mean	82.8	92.2	13.3	2.1
Desktop mean	8.1	4.9	94.3	86.3
Period 4				
Notebook mean	85.1	92.7	13.4	2.8
Desktop mean	7.3	6.4	92.7	78.5

The estimates of the proportions of time for the study computer's work-related use are shown in Table 5. Generally, the proportion of time the computers were used in support of teaching was relatively consistent across the first three periods, which included the fall and spring academic semesters. The teaching proportion declined slightly in favor of research and service during the fourth period (summer), especially for the notebook group.

TABLE 5 The proportions of time (in percent) for study computer use.

	Teaching	Service	Research	Other
Period 1				
Notebook mean	53.1	27.0	11.5	6.5
Desktop mean	47.0	28.0	14.6	10.4
Period 2				
Notebook mean	52.5	25.8	12.9	9.0
Desktop mean	52.0	30.5	11.3	5.8
Period 3				
Notebook mean	50.8	30.4	14.2	4.6
Desktop mean	51.8	27.6	9.4	10.7
Period 4				
Notebook mean	42.3	33.7	18.2	7.9
Desktop mean	45.7	35.9	11.3	7.1

Repairs. Data concerning the length of time required for computer repairs are shown in Table 6. The number of reported occurrences of the need for notebook computer repair generally exceeded that for desktops.

TABLE 6 The numbers of occurrences of needed computer repairs and the length of time required for the repairs, in days.

	Period 2	Period 3	Period 4
Notebook mean length	4.4	5.0	2.7
Desktop mean length	2.5	1.0	10.0
difference	*1.9*	*4.0*	*-7.3*
Notebook occurrences	8	1	6
Desktop occurrences	2	1	1

The types of problems reported for notebook computers in Periodic Surveys 2, 3 and 4 included the LS-120 SuperDrive (6 reports), hard disk drive (4), plastic backing, fan (14), Xircom card (5), battery clips (4), battery, keyboard, hinge, power management problems, computer lock up, cracked case, and problems associated with the migration to a new computer and with dialing into the network.

The types of problems reported for the study desktop computers in Periodic Surveys 2, 3 and 4 included the LS 120 SuperDrive (3), video card (4), "crashes," mouse, ethernet card, sound card, and modem.

Dial-in. Mean estimates of the number of hours spent on the USAFA dial-in service during the reporting period are shown in Table 7. The notebook user group spent more time per person on the dial-in service than the desktop user group across all periods,

including the period before the study started (Periodic Survey 1). The number of notebook users who took advantage of the dial-in service rose with the arrival of the new notebook computers (Periodic Surveys 2, 3 and 4).

Fifteen (37.5%) of the Desktop Group reported the use of the USAFA dial-in service for intranet access during the last reporting period of the study, spending 18.5 ± 26.5 hours on line during that period. Twenty-five (45.5%) of the Notebook group reported the use of the USAFA dial-in service for intranet access during the last reporting period of the study, spending 53.7 ± 57.0 hours on line. Ten (25%) of the Desktop Group reported problems with dial-in connections from home or from travel locations. Thirteen (23.6%) of the Notebook Group reported problems with dial-in connections from home or from travel locations.

TABLE 7 Hours spent on the USAFA dial-in service during the reporting period and the numbers of participants who used the dial-in service.

	Period 1	Period 2	Period 3	Period 4
Notebook mean length	26.6	36.6	33.4	29.2
Desktop mean length	16.4	17.9	12.5	22.0
difference	*10.2*	*18.6*	*20.9*	*7.2*
Number of notebook users	21	37	35	41
Number of desktop users	8	8	8	6

Training Attendance. Mean estimates of the number of hours spent in computer training during the reporting period are shown in Table 8. More members of the notebook user group attended training across all four periods. During the reporting period for Periodic Survey 1 (prior to the start of the study), desktop users spent more time per person in class.

TABLE 8 Hours spent in computer training during the reporting period and the numbers of participants who reported training attendance.

	Period 1	Period 2	Period 3	Period 4	Exit Survey
Notebook mean length	2.7	2.9	2.1	6.1	4.6
Desktop mean length	8.2	2.9	3.7	5.3	3.0
difference	*-5.5*	*0.0*	*-1.6*	*0.8*	*1.6*
Number of attendees from notebook group	14	14	9	11	15
Number of attendees from desktop group	5	6	3	7	6

Travel. Members of the notebook user group were more likely to bring a computer TDY. Data concerning the proportion of faculty traveling with a notebook computer is shown in Table 9.

TABLE 9 Number of faculty members traveling and the percentage accompanied by either the study notebook computer (notebook group) or other notebook computer (desktop user group).

	Number Traveling	Percentage Traveling with a Notebook Computer
Period 2		
Notebook Group	25	96%
Desktop Group	12	25%
Period 3		
Notebook Group	28	93%
Desktop Group	12	42%
Period 4		
Notebook Group	36	92%
Desktop Group	25	40%

The Desktop group was also asked if they had experienced problems in locating a notebook computer to use when they needed one, and only four (10%) responded that they did (exit survey).

Comments. All of the comments provided by the participants were assessed. Many participants provided more than one positive and/or negative comment on a Survey. Members of the notebook users group provided both a greater quantity of comments (both positive and negative) and a greater proportion of positive comments than members of the desktop users group. The distribution of positive and negative comments are shown in Table 10.

TABLE 10 Distribution of positive and negative comments.

|	Per 1	Per 2	Per 3	Per 4	Total
Desktop Positive					
Social Sciences	26	2	0	1	29
Basic Sciences	30	4	0	6	40
Engineering	40	5	2	3	50
Humanities	8	0	0	0	8
Sum	104	11	2	10	127
Desktop Negative					
Social Sciences	16	9	4	1	30
Basic Sciences	10	13	10	5	38
Engineering	30	12	7	5	54
Humanities	6	3	7	1	17
Sum	62	37	28	12	139
Notebook Positive					
Social Sciences	60	27	10	8	105
Basic Sciences	70	23	22	7	122
Engineering	34	19	3	8	64
Humanities	36	4	3	3	46
Sum	200	73	38	26	337
Notebook Negative					
Social Sciences	68	22	11	3	104
Basic Sciences	85	11	8	8	112
Engineering	34	10	5	15	64
Humanities	29	6	0	8	43
Sum	216	49	24	34	323
Grand Sum	582	170	92	82	926
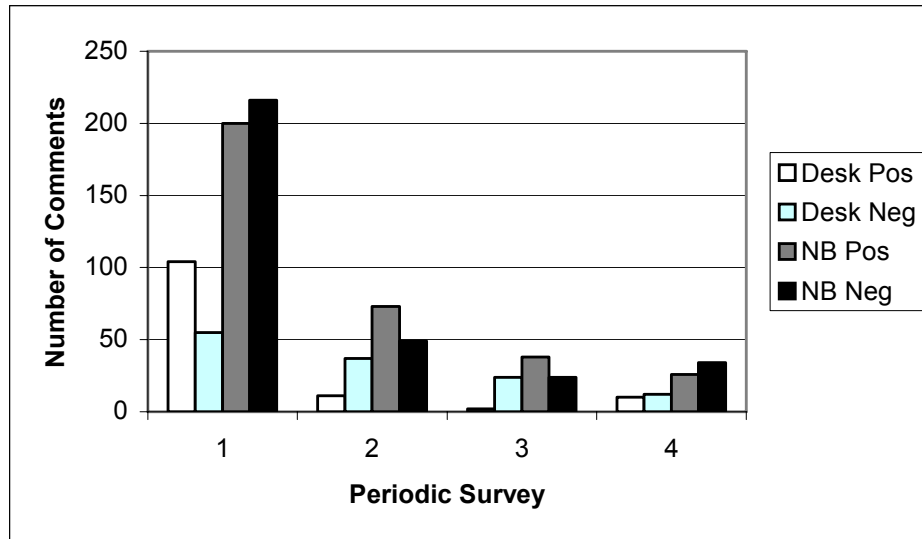
Figure 5 Summary of numbers of participant comments by Survey, computer type and affect. Desktop n = 75, notebook n = 90.

Ergonomic Concerns. The number of reports of pain likely to be associated with the nature of the workstations at which the computers were used are shown in Table 11. The numbers of reports of neck and shoulder pain were quite high at Periodic Survey 1 (before the start of the study). The study participants were able to request an ergonomic assessment through the on-line survey process. Approximately 20 ergonomic assessments were requested and conducted by one of the authors (JCM), including equal numbers of users in both groups. The sharp reduction in reports of neck and shoulder pain may be associated with those assessments and associated recommendations for workstation adjustments. There was a sharp increase in reports of wrist pain after the notebook computers were received by that user group (Periodic Survey 2). The subsequent decline may be related to the spontaneous and recommended acquisition and use of full-sized external keyboards by some members of the notebook user group.

TABLE 1 The numbers of reports of pain likely to be associated with the nature of the computer workstations.

	Neck	Shoulder	Back	Elbow	Wrist	Eye
Period 1						
Notebook count	10	7	6	0	3	5
Desktop count	27	29	2	0	8	3
Period 2						
Notebook count	2	4	3	3	11	6
Desktop count	3	1	2	0	7	4
Period 3						
Notebook count	3	1	2	0	9	2
Desktop count	6	2	1	0	4	1
Period 4						
Notebook count	1	2	0	0	7	1
Desktop count	3	1	1	0	5	2
Exit Survey						
Notebook count	2	2	6	4	14	7
Desktop count	3	2	1	0	4	2

The greater proportion of complaints in the Notebook Group was generated primarily by reports of back, elbow, wrist and eye pain.

Exit Survey Results

Of 106 respondents to the Exit Survey, 93 had completed the Entry Survey. Of these 93, 54 were in the Notebook Group and 39 were in the Desktop Group. The data of these 93 respondents are summarized here and, where practical, compared to their own subset of Entry Survey responses. Missing raw data among the 93 respondents were accounted for by using reduced sample sizes in respective calculations.

Inter-Group Comparisons. The two groups of Exit Survey respondents were compared for various aspects of computing and software. The scale ranged from 1, "very unsatisfactory," to 6, "very satisfactory." Although there were three group median differences of at least one unit on the rating scale (Intranet, World Wide Web, and Microsoft Excel), none of these differences was statistically significant.

The subjects were asked how often they used a computer in class, and what proportions of that time they used a notebook computer or a desktop. The results are shown in Table 12. The two groups did not differ significantly. Overall, the subjects tended to use a computer in the classroom about 34% of the time.

TABLE 12 Proportions of in-classroom computer use, in percent.

	Desktop Group			Notebook Group		
	Mean	**SD**	**n**	**Mean**	**SD**	**N**
Use computer in class	34.07	34.63	29	39.48	34.34	33
Use study notebook				28.52	40.79	33
Use different notebook	41.21	49.80	29	10.21	28.73	33
Use desktop	58.79	47.66	29	61.27	44.77	33

The Notebook Group was asked how often they took the study notebook computer out of the office. The distribution of responses is shown in Table 13. The mode and median of the distribution was 2 to 3 times per week.

TABLE 13 Distribution of reported frequency for taking the study notebook computer out of the office.

Category	Number of Responses
Never	1
Less than once per month	5
Less than once per week	4
Once per week	9
2 to 3 times per week	15
4 to 5 times per week	6
Once per day	9
More than once per day	4
No response	2

Both groups were asked about their overall experience with the study computer and its speed, response time and ergonomic design, compared to their previous computer. The distributions of responses are shown in Table 14. The four distributions of responses were each examined for inter-group differences using the Chi-squared test for independent samples (Siegel, 1956). The groups' responses were comparable for overall experience, speed and response time. The Notebook Group reported a slight improvement in ergonomic design (Chi-squared = 4.925, df = 1, $p < 0.05$). This ergonomic design response was counterintuitive, with respect to the inter-group difference in ergonomic complaints, unless the members of the Notebook Group had found solutions to their ergonomic problems.

TABLE 14 Distributions of responses (and rounded percentages) concerning overall experience with the study computer and its speed, response time and ergonomic design, compared to the pre-study computer (*p < 0.05).

	Desktop Group	Notebook Group
Overall Experience		
Better	32 (80%)	48 (89%)
Same	8 (20%)	6 (11%)
Worse	0 (0%)	0 (0%)
Speed		
Faster	30 (75%)	44 (81%)
Same	9 (22%)	9 (17%)
Slower	1 (2%)	1 (2%)
Response Time		
Better	28 (70%)	42 (78%)
Same	10 (25%)	10 (18%)
Worse	2 (4%)	2 (4%)
Ergonomic Design*		
Better	5 (12%)	17 (31%)
Same	23 (58%)	22 (41%)
Worse	12 (30%)	15 (28%)

On the exit survey, a series of questions were asked concerning the opinions of both the notebook and desktop users after having had experienced their computers for over a full year. The responses to these opinion questions are reported in Table 15.

TABLE 15 Distributions of responses (and rounded percentages) concerning opinion questions.

Nature of the Question	Yes for Desktop Group	Yes for Notebook Group
Will the next personal computer you buy be a notebook computer?	10 (25%)	28 (52%)
Should faculty members who want notebook computers get them?	36 (90%)	50 (92%)
Should incoming cadets get notebook computers?	24 (60%)	38 (70%)
Is the notebook computer sufficient for cadets in the course(s) you teach?	38 (95%)	48 (89%)

The Notebook Group was asked if they would trade the study notebook for a desktop computer. Only four (7%) said that they would. Conversely, the Desktop Group was asked if they would trade the study desktop for a notebook computer. Only two (5%) said that they would.

Pre-Post Comparisons. In Table 16, the two groups are compared across the Entry and Exit Surveys for "satisfaction" with various aspects of computing. The scale ranged from 1, "very unsatisfactory," to 6, "very satisfactory." Due to too few respondents among the desktop Group for the Entry Survey, no pre-post comparison was possible for that group concerning Notebook/Laptop Computer satisfaction nor for Dial-in satisfaction. There was one statistically significant difference for the Desktop Group: the median rating for Intranet satisfaction increased from 2 to 4 (n = 11, t = 3.5, p < 0.01, 2-tail). There were three statistically significant differences for the Notebook Group:

- The mean rating for Personal Computer satisfaction rose from 5.0 to 5.2 (n = 55, z = -3.04, p < 0.02, 2-tail).
- The mean rating for Notebook/Laptop Computer satisfaction rose from 4.5 to 5.2 (n = 29, z = -2.94, p < 0.02, 2-tail).
- The median rating for Intranet satisfaction rose from 4 to 5 (n = 52, z = -3.27, p < 0.02, 2-tail).

It was interesting to note that all three statistically significant changes for the Notebook Group occurred in the positive direction. The joint probability of that occurrence was 1 in 3^2, or about 0.012.

TABLE 16 Desktop vs. Notebook Group comparison across the Entry and Exit Surveys for "satisfaction" with various aspects of computing.

	Desktop Group				Notebook Group			
	Mean	SD	n	Median	Mean	SD	n	Median
Entry								
Personal computers	4.9	1.0	40	5	5.0	0.8	55	5
Notebook/Laptop computers	3.8	1.5	6	4.5	4.5	0.8	42	5
E-mail	4.7	1.4	11	5	5.2	0.8	51	5
Intranet	2.7	1.2	11	2	3.4	1.2	52	4
Web browsing	4.1	1.4	11	5	4.7	0.8	54	5
Dial-in	4.0	0.8	3	4	2.7	1.6	26	2
Exit								
Personal computers	4.9	1.0	40	5	5.2	0.9	55	5
Notebook/Laptop computers	5.2	0.8	20	5	5.2	1.0	39	5
E-mail	4.8	1.0	39	5	5.0	1.0	53	5
Intranet	4.1	1.3	40	4	4.2	1.3	55	5
Web browsing	4.3	1.3	40	5	4.3	1.1	55	4
Dial-in	1.9	2.1	40	4	3.7	1.6	26	4

DISCUSSION

The data collected during the periodic and exit surveys points to the following major findings, categorized by group for ease of reporting.

The notebook computer group:

- Reported higher satisfaction with their overall computer experience, computer speed, response time, and ergonomic design than desktop users.
- Provided a higher proportion of positive comments on the surveys than desktop users.
- Spent more time (per person) dialing in (after computers arrived, the number of notebook users dialing in was 4-7 times the number of desktop users dialing in) than desktop users.
- Took their computers home an average of 2-3 times per week. Only one member of the notebook group responded that they never took their computer home.
- Were more likely to travel with a computer.
- Used their notebook computers 93 percent of the time (compared to 80 to 85 percent for the desktop users).
- Used their computers more for research during the summer (Period 4).
- Reported more required repairs than desktop users.
- Added more hardware than the desktop group (mostly keyboards, mice, and monitors).
- Attended more technology training than desktop users.
- Suffered no losses due to theft or accidents.

The difference in satisfaction was unexpected. Since both groups received new computers, it was expected that the groups would be equally satisfied. The high satisfaction with ergonomic design for the notebook computer users was especially surprising. Most notebook users were somewhat concerned about ergonomic issues before receiving their computers. This result may be explained by ergonomic training before the start of the experiment and ergonomic consultations during the experiment.

The difference in proportion of positive comments may be explained by the design of the experiment. Members of the notebook computer group were not given their computers until they had responded to the entry survey and agreed to participate in the one-year study.

Results concerning time spent dialing in and the mobility of the computers between work, home, and professional travel locations were expected.

The fact that members of the notebook group used their computers 93 percent of the time (compared with 80-85 percent for the desktop group) points can also be explained by the portability of the computers. Rather than rely on computers in classrooms, in laboratories, at home, or at professional travel locations, notebook computer users could simply bring their personal computers with them to the various locations.

There are two possible explanations for difference in summer research use of the computers between the groups. There is a possibility that faculty members with heavier summer research commitments chose to be in the notebook computer group as a way to support their research efforts. An alternate explanation would be that the mobility of the notebook computers allowed faculty members to conduct more research.

The fact that the notebook computers required more repairs is not surprising – previous research predicted that result. Similarly, it is not surprising that notebook computer users added more hardware. We did find that most of the hardware additions were in the form of mice, keyboard and monitors to improve the ergonomics for the user. It should be noted that mice and keyboard are relatively inexpensive modifications.

The difference in the amount of technology training attended by the notebook computer users may be partially explained by an initial required briefing for that group. In addition to the initial mandatory training session, there was an additional optional "sharing" session for notebook computer users that may have positively influenced the training average for the notebook computer group.

Many members of the notebook group were concerned about security at the beginning of the study. Faculty from the Department of Law provided common-sense guidance, which was then passed to the faculty. In essence, the guidance was to treat the computer as they would any other expensive piece of government equipment. Faculty were told that if they exercised due diligence in protecting the computer, they would not be faulted if their computer was lost or stolen. In addition, faculty in the notebook group were issued locks and cables and given information concerning personal computer insurance. The study ended with no reports of loss due to theft or breakage.

Both Groups:

- Used computers in class about one-third of the time. Of this computer use, both groups used a desktop computer in class about 60% of the time.
- Reported ergonomic problems.

Since both groups contained an interdisciplinary mix of faculty members, the equality of classroom computer use is not surprising. The Air Force Academy is a "wired" campus any many classrooms house at least one computer and a projection device. The decision to use a computer in the classroom is dictated more by the subject matter than by the type of computer used by the individual faculty members. Notebook

computers may have made it easier for members of the notebook group to plan computer-aided lessons and may have lessened classroom set-up time.

Again, the mention of ergonomics in the initial and periodic surveys probably served to heighten awareness of ergonomic issues in both groups. Although we expected a higher incidence of ergonomic problems among notebook users, many desktop users were made aware of poor work habits and office environments.

CONCLUSIONS AND RECOMMENDATIONS

This research confirms that notebook computers are indeed a valuable addition to the computing "mix" for faculty at the United States Air Force Academy. By issuing notebook computers to faculty who are willing to give up their desktop machines, we were able to increase the mobility and flexibility of faculty members throughout the course of the study. Giving the faculty the opportunity to choose produced many positive results including increased satisfaction with their computers. The ability to work from home or remote locations without being encumbered by file transfers or floppy disks certainly aids faculty productivity.

Of all the data collected, only one negative for notebook computers emerged – number of required repairs. Although notebook computers will probably always be subject to more potential for breakage, manufacturers are responding by creating more robust computers. On the positive side, the ability to transport the computers makes travel to and from repair sites quicker and easier. This one-year study did not address lifespan or "wear and tear" issues. Additional longitudinal research is this area is recommended.

Ergonomic consultations were offered to 152 participants, and 27 requested them. Thus, the prevalence of ergonomic disorders was approximately 18 percent. This value suggests that another similar proportion of faculty members may suffer from ergonomic disorders associated with their computer workstations with many suffering from multiple symptoms. This is a significant number of people. Efforts should be made to provide ergonomic training all computer users.

It is common practice in the Air Force to provide notebook computers to members on official travel orders. Faculty members in the Notebook computer group were able to perform their duties in remote locations with access to only one computer. An additional study should be accomplished in the Air Force in which desktop computers are replaced by notebooks for those who travel frequently. This study could determine whether "travel" notebooks could be eliminated, thus reducing the overall computer budget for affected units.

The data acquired to date and to be acquired in subsequent studies with cadets should provide a research basis that will help identify potential applications of notebook computers across many Air Force and Department of Defense missions.

Appendix A (Survey Control Number 98-44)

Faculty Computer Study
Entry Survey

Last name:_____ Please capitalize first letter.
First name: _____ Please capitalize first letter.
Department: _____ Please capitalize all letters.
Gender: _____Male _____ Female
Age (years): _____
Academic Rank: _____
Amount of Education: _____
Status/Military rank: _____
If rank, education, or status is "Other," explain: _____

Number of years of experience with:

All computers (mainframe, mini, PC, etc.): _____ years
     *Of these years, just personal (desktop, notebook, etc.):   computers
     _____ years
     *Of these years, just laptop/notebook computers: _____ years
Internet E-mail: _____ years
USAFA intranet: _____ years
Web browsing: _____ years
USAFA dial-in service: _____ years
Other dial-in service (ISP, etc.): _____ years

Languages in which you have written code (select all that apply).

____Interpreted Basic   ____ Compiled Basic   ____ FORTRAN
____ COBOL   ____ Pascal   ____ DOS batch
____ HTML   ____ CGI Other

What kind of desktop will you be giving up? _____

Operating System: _____   RAM: _____ Mb

Overall, how satisfied are you with the following?
(select one option per line; where 1 is Very Unsatisfactory and 6 is Very Satisfactory)
Overall Satisfaction with:
  * Personal Computers   1 2 3 4 5 6
  * Laptop/Notebook Computers   1 2 3 4 5 6 N/A
  * Internet E-mail   1 2 3 4 5 6 N/A
  * USAFA intranet   1 2 3 4 5 6 N/A
  * Web browsing   1 2 3 4 5 6 N/A
  * USAFA dial-in service   1 2 3 4 5 6 N/A

Benefits you expect to derive by switching from your old USAFA desktop to the new computer:

_____
_____
_____
_____

Disadvantages you expect to experience by switching from your old USAFA desktop to the new computer:

_____
_____
_____
_____

Appendix B (Survey Control Number 98-44)

Faculty Computer Study
Periodic Survey

Last name: _____ Please capitalize the first letter.
First name: _____ Please capitalize the first letter.
Department: _____ Please capitalize all letters

Please answer for your current work computer from May 22, 1999 to August 11, 1999.
(What you did over your summer vacation...)

How satisfactory has this computer been for application programs? (select one
option per line; Where 1 is Very Unsatisfactory and 6 is Very Satisfactory You must
select a response for every question, even if it is "N/A.")
Overall Satisfaction with:
  * MS Word   1 2 3 4 5 6 N/A
  * MS Excel   1 2 3 4 5 6 N/A
  * MS Access   1 2 3 4 5 6 N/A
  * MS Outlook   1 2 3 4 5 6 N/A
  * Language Compiler   1 2 3 4 5 6 N/A
  * MS PowerPoint   1 2 3 4 5 6 N/A
  * PaintShop Pro   1 2 3 4 5 6 N/A
  * PhotoShop   1 2 3 4 5 6 N/A
  * MS Internet Explorer   1 2 3 4 5 6 N/A
  * MS FrontPage   1 2 3 4 5 6 N/A
  * MS Personal Web Server 1 2 3 4 5 6 N/A
  * Netscape Navigator   1 2 3 4 5 6 N/A
  * Netscape Composer   1 2 3 4 5 6 N/A
  * Mathematica   1 2 3 4 5 6 N/A
  * CAD program   1 2 3 4 5 6 N/A
  * Q2i   1 2 3 4 5 6 N/A
  * Grader   1 2 3 4 5 6 N/A
  * Other Program   1 2 3 4 5 6 N/A
  * Other Program   1 2 3 4 5 6 N/A
  * Other Program   1 2 3 4 5 6 N/A
  * Other Program   1 2 3 4 5 6 N/A
  * Other Program   1 2 3 4 5 6 N/A

How often have you used these options?
(select one per line where 1 = Never, 4 = Sometimes, and 7 = Always)
Frequency you have used:
  * CD-ROM   1 2 3 4 5 6 7
  * Ethernet (standard non-modem desktop connection) 1 2 3 4 5 6 7
  * Modem   1 2 3 4 5 6 7
  * Other   1 2 3 4 5 6 7 N/A
  * Other   1 2 3 4 5 6 7 N/A

Have you used any additional hardware with this computer? (scanner, digital camera, docking station, external monitor, external keyboard, printer, etc.) _____ yes _____ no

If yes, please describe:

Have you used any additional software with this computer?
_____ yes _____ no

If yes, please describe:

Approximate proportion of time for ALL computer use (home, work, personal, etc.: total must equal 100%)
Laptop/notebook __ %
      Of this use, what proportion was the study notebook _____ % (0 - 100%)
      Desktop users enter zero
Desktop _____ %
      Of this use, what proportion was the study desktop _____ % (0 - 100%)
      Notebook users enter zero
Total for notebook and desktop must equal 100%

Approximate proportions of time for your study computer's use: (total must equal 100%)

Teaching: _____ % (lesson prep, course mgt, multimedia, etc.)
Service: _____ % (professional and additional duties, etc.)
Research: _____ % (data entry, analysis, presentations, etc.)
Other: _____ % (work related)
Total must equal 100%
Computer-related ergonomic problems (check all that apply):

_____ Neck pain   _____ Shoulder pain   _____ Back pain
_____ Elbow pain   _____ Wrist pain   _____ Eye pain
_____ Other pain   _____ None

If problems exist, do you want an ergonomics consultation?
_____ yes _____ no

Did your computer require hardware repairs?
_____ yes _____ no
If yes, please describe: _____
If yes, how many days was the computer in the shop? _____ days
If it was in the shop, how did you accomplish your computer-dependent work while it was gone? _____

Approximately how many hours did you spend on the USAFA dial-in service? ____ hrs

How many hours of computer hardware/software training did you attend? _____ hrs
If you attended, please describe:

How often did you use a computer in your classroom? _____ % (0-100%)
Of this use, what proportion was the study notebook _____ %
(0 - 100%)
Of this use, what proportion was another notebook _____ %
(0 - 100%)
Of this use, what proportion was the classroom desktop _____ %
(0 - 100%)

How many days were you TDY during this time? _____ days
Notebook participants only:
On how many days of travel (leave or TDY) did your study computer accompany you?
_____ days

NT desktop participants only:
On how many days of travel (leave or TDY) did a laptop/notebook accompany you?
_____days

Both groups:
1. Are there any topics or training not covered by your OCM, that you would like to see addressed in a users group meeting? If so, please list them here:
_____
_____
_____
_____

2. Additional Comments: Please discuss any additional uses, perceived advantages or disadvantages of your study computer.
_____
_____
_____
_____

Thank you for participating in the Faculty Computer Study!

This survey was constructed for the Faculty Computer Study by Dr. Peg Halloran, IITA, Dr. Jay Miller, HERC and Maj Marie Revak, DFE. Web page authored by Ms. Carolyn Dull, DFE and modified by Dr. Peg Halloran, IITA. Questions about this form should be addressed to Maj Marie Revak, Dr. Peg Halloran or Dr. Jay Miller.

Appendix C (Survey Control Number 98-44)

Faculty Computer Study
Exit Survey

Last name: _____ Please capitalize the first letter.
First name: _____ Please capitalize the first letter.
Department: _____ Please capitalize all letters, e.g., DFB

Please answer for your current work computer for Fall Semester 1999 (August 12 to December 10, 1999)

Overall, how satisfied are you with the following?
(select one option per line; where 1 is Very Unsatisfactory and 6 is Very Satisfactory)
Overall Satisfaction with:
  * Personal Computers   1 2 3 4 5 6
  * Laptop/Notebook Computers   1 2 3 4 5 6 N/A
  * Internet E-mail   1 2 3 4 5 6 N/A
  * USAFA intranet   1 2 3 4 5 6 N/A
  * Web browsing   1 2 3 4 5 6 N/A
  * USAFA dial-in service   1 2 3 4 5 6 N/A

How satisfactory has this computer been for application programs? (select one option per line; Where 1 is Very Unsatisfactory and 6 is Very Satisfactory. You must select a response for every question, even if it is "N/A.")
Overall Satisfaction with:

* MS Word	1 2 3 4 5 6 N/A
* MS Excel	1 2 3 4 5 6 N/A
* MS Access	1 2 3 4 5 6 N/A
* MS Outlook	1 2 3 4 5 6 N/A
* Language Compiler	1 2 3 4 5 6 N/A
* MS PowerPoint	1 2 3 4 5 6 N/A
* PaintShop Pro	1 2 3 4 5 6 N/A
* PhotoShop	1 2 3 4 5 6 N/A
* MS Internet Explorer	1 2 3 4 5 6 N/A
* MS FrontPage	1 2 3 4 5 6 N/A
* MS Personal Web Server	1 2 3 4 5 6 N/A
* Netscape Navigator	1 2 3 4 5 6 N/A
* Netscape Composer	1 2 3 4 5 6 N/A
* Mathematica	1 2 3 4 5 6 N/A
* CAD program	1 2 3 4 5 6 N/A
* Q2i	1 2 3 4 5 6 N/A
* Grader	1 2 3 4 5 6 N/A
* Other Program	1 2 3 4 5 6 N/A
* Other Program	1 2 3 4 5 6 N/A
* Other Program	1 2 3 4 5 6 N/A
* Other Program	1 2 3 4 5 6 N/A
* Other Program	1 2 3 4 5 6 N/A

How often have you used these options?
(select one per line where 1 = Never, 4 = Sometimes, and 7 = Always)
Frequency you have used:

* CD-ROM	1 2 3 4 5 6 7
* Ethernet (standard non-modem desktop connection)	1 2 3 4 5 6 7
* Modem	1 2 3 4 5 6 7
* Other	1 2 3 4 5 6 7 N/A
* Other	1 2 3 4 5 6 7 N/A

Have you used any additional hardware with this computer? (scanner, digital camera, docking station, external monitor, external keyboard, printer, etc.) _____ yes _____ no

If yes, please describe:

Have you used any additional software with this computer?
_____ yes _____ no

If yes, please describe:

8

Approximate proportion of time for ALL computer use (home, work, personal, etc.: total must equal 100%)
Laptop/notebook _____ %
        Of this use, what proportion was the study notebook _____ % (0 - 100%)
        Desktop users enter zero
Desktop _____ %
        Of this use, what proportion was the study desktop _____ % (0 - 100%)
        Notebook users enter zero
Total for notebook and desktop must equal 100%

Approximate proportions of time for your study computer's use: (total must equal 100%)

Teaching: _____ % (lesson prep, course mgt, multimedia, etc.)
Service: _____ % (professional and additional duties, etc.)
Research: _____ % (data entry, analysis, presentations, etc.)
Other: _____ % (work related)
Total must equal 100%

Computer-related ergonomic problems (check all that apply):

_____ Neck pain   _____ Shoulder pain   _____ Back pain
_____ Elbow pain   _____ Wrist pain   _____ Eye pain
_____ Other pain   _____ None

If problems exist, do you want an ergonomics consultation?
_____ yes _____ no

Did your computer require hardware repairs? _____ yes _____ no
If yes, please describe: _____
If yes, how many days was the computer in the shop? _____ days
If it was in the shop, how did you accomplish your computer-dependent work while it was gone? _____

Approximately how many hours did you spend on the USAFA dial-in service?
_____ hrs

Have you had any trouble using dial-in to connect to the USAFA from home, or while TDY (from hotels, airports etc.)
_____ yes _____ no

If yes, please explain: _____

How many days were you TDY during this time? _____ days

How many hours of computer hardware/software training did you attend? _____
hrs
If you attended, please describe: _____

How often did you use a computer in your classroom? _____% (0-100%)
Of this use, what proportion was the study notebook _____%
(0 - 100%)
Of this use, what proportion was another notebook _____%
(0 - 100%)
Of this use, what proportion was the classroom desktop_____ %
(0 - 100%)

Notebook participants only:
On how many days of travel (leave or TDY) did your study computer accompany you?
_____days

On average, how many times per week did your notebook computer leave your office?

If given a choice, would you trade your notebook computer for a desktop computer?
_____ yes _____no

If yes, please explain: _____

Please describe any specific events that helped confirm your decision:
_____
_____
_____
_____

NT desktop participants only:
On how many days of travel (leave or TDY) did a laptop/notebook accompany you?
_____ days

Did you have trouble finding a notebook computer when you needed one? _____ yes
_____ no

If given a choice, would you trade your desktop computer for a laptop/notebook
computer? _____ yes _____ no

If yes, please explain:
_____

Please describe any specific events that helped confirm your decision:
_____
_____
_____

Both groups:
How did your study computer compare to the desktop you turned in at the beginning of this study?

It was the same, faster, slower.
It had the same, better, worse response time.
It had the same, better, worse ergonomic design.
Overall, I had the same, better, worse experience with the study machine.

Will the next PC that you purchase for home use be a notebook or a desktop?
_____ desktop _____ notebook

Please answer the following group of questions, solely based on your own experience. By design, the option "no opinion" has been eliminated from the list, so please select either "yes" or "no".

Would you recommend that all faculty members who want notebook computers be given one? _____ yes _____ no

Would you recommend that incoming cadets be issued notebook computers? _____ yes _____ no

Would you recommend that ALL classes of cadets be issued notebook computers? _____ yes _____ no

Would the study notebook computers suffice for everything cadets need to do in the classes you teach? _____ yes _____ no

Benefits you experienced by switching from your old USAFA desktop to the new computer: Consider all issues including screen size, keyboard, mouse, security, operating system, ergonomics, power, reliability, stability, memory, work habits, compatibility with other hardware and software etc.

_____
_____
_____
_____

Disadvantages you experienced by switching from your old USAFA desktop to the new computer: Consider all issues including screen size, keyboard, mouse, security, operating system, ergonomics, power, reliability, stability, memory, work habits, compatibility with other hardware and software etc.

_____
_____
_____
_____

Additional Comments: Please discuss any additional uses, perceived advantages or disadvantages of your study computer.

_____
_____
_____
_____

Thank you for participating in the Faculty Computer Study!

This survey was constructed for the Faculty Computer Study by Dr. Peg Halloran, IITA, Dr. Jay Miller, HERC and Maj Marie Revak, DFE. Web page authored by Dr. Peg Halloran, IITA. Questions about this form should be addressed to Maj Marie Revak.

Endnotes

[1] http://www.vcsu.nodak.edu/offices/itc/notebooks/other.htm
[2] The project was submitted for review by the USAFA Institutional Review Board, and was judged exempt by the IRB as a "normal educational practice."
[3] These data were presented originally as Miller et al., 1999.

REFERENCES

Babbitt BA and Nystrom CO (1989). *Questionnaire Construction Manual*. US Army Research Institute for the Behavioral and Social Sciences, Ft Hood TX.

Miller JC, Halloran ME, Revak MA (1999). The 1999 Faculty Notebook Computer Study: Entry Survey Data. In Miller JC, Halloran ME, Millis BJ (ed.). *Pikes Peak Educational Innovations and Research Symposium* (Proceedings). Technical Report HERC 1999-01, Dean of the Faculty, USAF Academy, Colorado, pp 78-85. (AD A363716PAA).

Siegel S (1956). *Nonparametric Statistics for the Behavioral Sciences*. McGraw-Hill, New York.

ABOUT THE INSTITUTE

The Institute for Information Technology Applications (IITA) was formed in 1998 to provide a means to research and investigate new applications of information technology. The Institute encourages research in education and applications of the technology to Air Force problems that have a policy, management, or military importance. Research grants enhance professional development of researchers by providing opportunities to work on actual problems and to develop a professional network.

Sponsorship for the Institute is provided by the Secretary of the Air Force for Acquisition, the Air Force Office of Scientific Research, and the Dean of Faculty at the U.S. Air Force Academy. IITA coordinates a multidisciplinary approach to research that incorporates a wide variety of skills with cost-effective methods to achieve significant results. Proposals from the military and academic communities may be submitted at any time since awards are made on a rolling basis. Researchers have access to a highly flexible laboratory with broad bandwidth and diverse computing platforms.

To explore multifaceted topics, the Institute hosts single-theme conferences to encourage debate and discussion on issues facing the academic and military components of the nation. More narrowly focused workshops encourage policy discussion and potential solutions. IITA distributes conference proceedings and other publications nation-wide to those interested or affected by the subject matter.