A COMPARISON OF USER SATISFACTION WITHIN COMPUTING CONTEXT - PC vs. MAINFRAME

Jang, Si Young

Assistant Professor
Dept. of Public Administration
Sung Kyun Kwan University

August 1989

ABSTRACT

This paper addresses the "PC vs. mainframe" issue by systematically evaluating the usefulness of PCs in an educational context. For this purpose the satisfaction of 47 undergraduate students working with a software package that is available on both PCs and the mainframe was measured and analyzed.

The results of the analysis of variance show no interaction effects between computing context and computing experience. Users were more satisfied with PC LINDO than with its mainframe counterpart. Also experienced users showed significantly higher satisfaction than inexperienced users in this study.

1. INTRODUCTION

As the number of personal computers (PCs) has increased in educational settings, researchers have begun to question whether the benefits of PCs as a teaching tool are equivalent to those of mainframe computers[3, 7]. The purpose of this study is to address this "PC vs. mainframe" issue by systematically evaluating the usefulness of PCs in an educational context. If PCs are as effective as (or more effective than) mainframe computers in some educational environments, it is possible that some of the teaching functions could be off-loaded from the mainframes to the PCs.

One method of evaluating these two approaches is to compare the satisfaction[8, 11] of student users working with a software package that is available on both the PC and the mainframe. In order to solve linear programming (LP) problems by computer, all students registered in Management Science courses at the University of Pittsburgh[1] are required to use LINDO (Linear, Interactive, aNd Discrete Optimizer) package - either on PCs or on the mainframe computer. LINDO is one of the easy-to-use computer packages. Both PC and mainframe (VAX/VMS) versions of LINDO are available at the University of Pittsburgh, and both versions have exactly the same execution process. The major differences between these two versions are in the login/ booting procedure and printout formats.

Some instructors of Management Science insist on students using mainframe computers while others believe, without empirical evidence, that the PC version of LINDO is advisable for undergraduate students majoring in Business. At this time, it is not clear which of these two options is more effective in teaching the students how to use LINDO. This paper reports the results of an experiment in which two groups of students were assigned a single problem and asked to solve it using, in one case, the IBM PC, and in the other, the VAX mainframe. Because prior computing experience has been shown to influence student attitudes about the computer[7], this "moderating" variable was also considered as a secondary independent variable[4].

---

[1] This study was carried out while the author was teaching Management Science at the University of Pittsburgh.

2. THE EXPERIMENT

A. Subjects

Forty-seven undergraduate students registered in two evening sections of an introductory level Management Science class participated in the experiment. Most of them (45) were Business majors. All of the subjects were in their junior or senior year. More than half of the students (57%) had no prior programming experience. Only 20 out of 47 had programmed previously.

B. Experimental Design

A quasi-experimental method[2] was used to investigate the effects of computing context (PC vs. mainframe) and users' computing experience on the level of user satisfaction with the computer systems. Because intact classes were used, complete random assignment of subjects could not be achieved. Instead, PC LINDO was assigned to one class of students and the mainframe version to the other. For the purposes of this experiment, however, students were assumed to have been randomly divided into two classes.

Each class was then divided into two subgroups, based on the existence of prior computing experience. Although computing experience does not constitute an experimental treatment, subjects were divided on this basis to isolate any potential effect of experience on attitude from the effect of computing context. Figure 1 shows the overall experimental design and the number of subjects in each subgroup.

COMPUTING CONTEXT

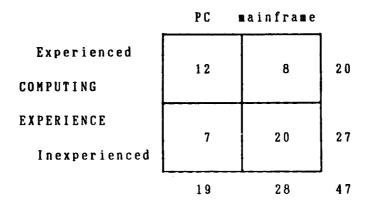|	PC	mainframe	
Experienced	12	8	20
Inexperienced	7	20	27
	19	28	47

(COMPUTING EXPERIENCE)

Figure 1: Number of Subjects in Each Subgroup

This experiment was carried out in January 1988 over a two week period. In the first week, a moderate set of assignments,[2] consisting of a maximization problem with post-optimality analysis, was given to the subjects in both classes for solution using LINDO package. In the following week, immediately after the LINDO assignments were collected, a questionnaire was administered to measure the level of user satisfaction with the computer systems.

3. HYPOTHESES

Based on this experimental design, the following three hypotheses were generated:

Hypothesis 1: There is no interaction between computing context and computing experience.

If this hypothesis is rejected, a contingency result is obtained. Otherwise, hypotheses 2 and 3 are tested.

Hypothesis 2: There is no difference in user satisfaction between the PC and mainframe subgroups.

Hypothesis 3: There is no difference in user satisfaction between the experienced and inexperienced subgroups.

4. MEASUREMENT

In this experiment, the dichotomous variable, prior computing experience, was operationalized based on the self-reported response to the question: Have you performed computer programming before?[3]

For the measurement of user satisfaction with PC LINDO and mainframe LINDO, a subset of user satisfaction items developed by Bailey and Pearson[1] was used. These authors suggest that it is reasonable to remove irrelevant factors from the comprehensive set and to redefine the factors in situation-specific terms.

---

[2] The assignments were moderate in that the optimal solution could be obtained instantly by the computers, while solution by hand would require the whole single session.

[3] Most students (93.6%) responded that they had used the computers before. For the dichotomy here, computing experience was defined on the basis of the existence of programming experience.

The criteria used in selecting the user satisfaction items were as follows:

1. Organizational factors were removed because each subject was expected to run LINDO on his own (factors 1-12, 26, 33, 34, 36, 37).

2. Since both PC and mainframe LINDO provide exactly the same output in terms of accuracy, reliability, volume, etc., these common output factors were removed (factors 16, 18-21, 23-25).

3. Adaptability (ease of change) factors were dropped because this study focused on satisfaction at a single point of time (factors 27, 28, 35, 38, 39).

After applying these criteria, the following nine factors remained to measure and analyze the user satisfaction of the four subgroups of students.

1. Response Time
2. Mode of Interface
3. Convenience of Access
4. Timeliness of Output
5. Format of Output
6. Expectations
7. Understanding of Systems
8. Perceived Utility
9. Confidence in the Systems

The complete set of questionnaire items is included as an Appendix.

Each factor has four bipolar adjective pairs ranging from a negative to a positive feeling. The scaling of the seven intervals in each pair was quantified by assigning the values -3, -2, -1, 0, 1, 2 and 3 to the intervals. Each factor was assigned equal weight following Ives et al.'s[6] recommendation. Therefore, the reaction of an individual to a given factor is the average of the four assigned values;

$$Rij = \frac{1}{4} \sum_{k=1}^{4} Iijk$$

where

    Iijk = the numeric response of user i to adjective pair k of factor j

By summing the individual factor responses, the overall satisfaction for the user i is obtained;

$$Si = \sum_{j=1}^{9} Rij$$

The range of Si is from -27 to 27.

5. RESULTS OF THE STUDY

   The sample means of Overall Satisfaction for the four
subgroups are shown in Figure 2. The overall mean score for
all groups combined was 16.93 (out of 27). Following Bailey
and Pearson's[1] classification scheme, the subjects can be
said to be "quite satisfied" in using LINDO on both computer
systems. (The normalized score was 16.93/27=0.63.)

COMPUTING CONTEXT

	PC	mainframe	
Experienced	20.13 (n=12)	17.88 (n=8)	19.23 (n=20)
Inexperienced	18.71 (n=7)	14.01 (n=20)	15.23 (n=27)
	19.61 (n=19)	15.12 (n=28)	16.93 (n=47)

COMPUTING EXPERIENCE

Figure 2: Sample Means of Overall Satisfaction for
            Subgroups

   Since this experimental design involves unequal cell
size, two-way analysis of variance (ANOVA) using a
regression approach was used. This method has the advantage
that the logical flow of decisions made in the analysis does
not directly correspond to the actual order in which the
computations are usually performed[9]. The results of the
ANOVA are presented in Table 1. The interaction effect is
not significant. Neither are the two partial effects.
However, both of the main effects (CONTEXT and EXP) are
significant at the 0.05 level.
   In order to explain the differences in Overall
Satisfaction in terms of computing context and programming
experience, subgroup sample means were calculated (Table 2)
and ANOVA performed for each factor (Table 3). Note that
none of the interaction effects were significant.

Table 1: ANOVA Summary Table for Overall Satisfaction

Source	F-value	PR > F
CONTEXT×EXP	0.43	.517
CONTEXT|EXP	3.53	.067
EXP|CONTEXT	2.25	.141
CONTEXT	6.49	.015*
EXP	5.22	.027*

*significant at 0.05 level

Table 2: Subgroup Sample Mean for Each Factor

Factor	PC/Exp (n=12)	PC/Inexp (n=7)	Main/Exp (n=8)	Main/Inexp (n=20)	Factor Mean (n=47)
Response Time	2.46	2.50	2.69	2.34	2.45
Interface	2.51	2.32	1.94	1.74	2.06
Access	2.42	2.11	1.47	1.25	1.71
Timeliness	2.67	2.39	2.09	2.05	2.27
Format	2.54	2.18	2.13	2.08	2.22
Expectations	1.94	2.00	2.34	1.80	1.96
Understanding	1.60	1.25	1.25	0.43	0.99
Utility	2.17	2.07	1.81	1.56	1.84
Confidence	1.79	1.89	2.16	0.78	1.44
Overall Satisf.	20.13	18.71	17.88	14.01	16.93

Table 3: ANOVA Results for Each Factor

Factor	Interaction (CONTEXT×EXP)	Main Effect (CONTEXT)	Main Effect (EXP)
Response Time	0.70 (.407)[a]	0.03 (.870)	0.61 (.439)
Interface	0.00 (.973)	5.70 (.021)*	2.21 (.145)
Access	0.01 (.919)	5.63 (.022)*[b]	1.86 (.180)
Timeliness	0.18 (.676)	3.86 (.056)	1.38 (.247)
Format	0.39 (.536)	1.83 (.183)	1.37 (.249)
Expectations	1.24 (.271)	0.00 (.984)	0.96 (.333)
Understanding	0.24 (.627)	3.24 (.079)	3.38 (.073)
Utility	0.06 (.801)	3.02 (.090)	1.35 (.252)
Confidence	2.71 (.107)	2.43 (.126)	4.33 (.044)*
Overall Satisf.	0.43 (.517)	6.49 (.015)*	5.22 (.027)*

*significant at 0.05 level
[a]F-value (PR > F)
[b]F(CONTEXT|EXP) also significant at 0.05 level

Out of nine factors that are assumed to constitute Overall Satisfaction, three factors were found to be significant at the 0.05 level of significance - Mode of Interface, Access, and Confidence. These results suggest that PCs provide a superior interface and are more convenient to access than the mainframe computer, regardless of prior computing experience. Experienced users were generally more confident about the computer system than inexperienced users, whether they used PCs or the mainframe computer.

6. SUMMARY AND CONCLUSION

In this study, the satisfaction of two groups of undergraduate students, using PC LINDO and mainframe LINDO, respectively, was measured and analyzed. Some interesting results were obtained.

First, the subjects in this experiment were "quite satisfied" according to Bailey and Pearson's[1] classification of score boundaries (normalized score=0.63). This is probably a result of the easy-to-use nature of the LINDO package.

Second, no interaction was found to exist between computing context and students' prior experience with computer programming. Furthermore, no interaction effects were observed in any factor of user satisfaction.

Third, PCs appear to provide significantly higher user satisfaction than the mainframe computer regardless of users' prior experience. Students seemed to be more satisfied with PCs because of the PCs' clear interface and convenient access. This may be explained by the fact that mainframe systems require specific terminals and/or modems for communication and have complicated procedures for login.

Finally, experienced users showed significantly higher satisfaction than inexperienced users. The differences were found in both the PC and mainframe contexts and the source of differences may be attributable to the "confidence in systems" factor.

Interpretation of the experimental results requires caution, however. The scope of the study is quite limited - in its task, time scale, and individual difference dimensions[10]. The task is a simple one, and the measurement was confined to performance only - learning and development were not involved.

Second, the instrument used in this study may suffer from "Factor Heterogeneity." Since the overall satisfaction of the users was derived by summing all factors, a potential weighting problem may exist in the measurement tool itself[5].

Nevertheless, the study results indicate that LINDO assignments could be safely off-loaded from the mainframe computer. This reinforces the trend toward greater usage of PCs in education.

Appendix. Questionnaire Items

1. The <u>elapsed time</u> between my request for execution of LINDO and the return of the output is;

```
        fast :___:___:___:___:___:___:___: slow
        good :___:___:___:___:___:___:___: bad
  consistent :___:___:___:___:___:___:___: inconsistent
  reasonable :___:___:___:___:___:___:___: unreasonable
```

2. The <u>method and medium</u> by which I input data to and receive output from the computer system are;

```
   convenient :___:___:___:___:___:___:___: inconvenient
        clear :___:___:___:___:___:___:___: hazy
    efficient :___:___:___:___:___:___:___: inefficient
    organized :___:___:___:___:___:___:___: disorganized
```

3. The <u>ease or difficulty</u> with which I act to utilize the capability of the computer system is;

```
   convenient :___:___:___:___:___:___:___: inconvenient
         good :___:___:___:___:___:___:___: bad
         easy :___:___:___:___:___:___:___: difficult
    efficient :___:___:___:___:___:___:___: inefficient
```

4. The <u>availability of the LINDO output information</u> at a time suitable for its use is;

```
       timely :___:___:___:___:___:___:___: untimely
   reasonable :___:___:___:___:___:___:___: unreasonable
   consistent :___:___:___:___:___:___:___: inconsistent
     punctual :___:___:___:___:___:___:___: tardy
```

5. The <u>material design of the layout and display</u> of the LINDO output contents is;

```
         good :___:___:___:___:___:___:___: bad
       simple :___:___:___:___:___:___:___: complex
     readable :___:___:___:___:___:___:___: unreadable
       useful :___:___:___:___:___:___:___: useless
```

6. The <u>set of attributes or features</u> of the computer information services that I consider reasonable and due from the computer system is;

```
     pleasing :___:___:___:___:___:___:___: displeasing
         high :___:___:___:___:___:___:___: low
     definite :___:___:___:___:___:___:___: uncertain
   optimistic :___:___:___:___:___:___:___: pessimistic
```

7. The <u>degree of comprehension</u> that I possess about the
computer system or services that are provided is;

         high :___:___:___:___:___:___:___: low
   sufficient :___:___:___:___:___:___:___: insufficient
    complete :___:___:___:___:___:___:___: incomplete
        easy :___:___:___:___:___:___:___: hard

8. My judgment about the <u>relative balance between the cost
and the considered usefulness</u> of the computer information
products or services that are provided is;

        high :___:___:___:___:___:___:___: low
    positive :___:___:___:___:___:___:___: negative
   sufficient :___:___:___:___:___:___:___: insufficient
      useful :___:___:___:___:___:___:___: useless

9. My feelings of <u>assurance or certainty</u> about the systems
or services provided are;

        high :___:___:___:___:___:___:___: low
      strong :___:___:___:___:___:___:___: weak
    definite :___:___:___:___:___:___:___: uncertain
        good :___:___:___:___:___:___:___: bad

References

[1] Bailey, J.E. and Pearson, S.W., "Development of a Tool
for Measuring and Analyzing Computer User
Satisfaction," <u>Management Science</u>, Vol. 29, No. 5,
pp.530-545, 1983.

[2] Campbell, D.T. and Stanley, J.C., <u>Experimental and
Quasi-Experimental Designs for Research: Handbook of
Research on Teaching</u>, Rand McNally, Skokie, Illinois,
1963.

[3] Cyert, R.M., "Personal Computing in Education and
Research," <u>Science</u>, Vol. 222, No. 4624, 1983.

[4] Emory, C.W., <u>Business Research Methods</u>, Richard D.
Irwin, Inc., Homewood, Illinois, pp.94-97, 1976.

[5] Galletta, D.F. and Lederer, A.L., "Some Cautions on the
Measurement of User Information Satisfaction," Working
Paper 643, University of Pittsburgh, 1986.

[6] Ives, B., Olson, M.H. and Baroudi, J.J., "The Measurement of User Information Satisfaction," Communications of the ACM, Vol. 26, No. 10, pp.785-793, 1983.

[7] King, W.R., Raghunathan, T.S. and Teng, J., "Personal Computers in Business Education: An Experimental Assessment," Omega, Vol. 14, No. 4, pp.317-323, 1986.

[8] King, W.R. and Rodriguez, J.I., "Evaluating Management Information Systems," MIS Quarterly, Vol. 2, No. 3, pp.43-51, 1978.

[9] Kleinbaum, D.G. and Kupper, L.L., Applied Regression Analysis and Other Multivariable Methods, Duxbury Press, Boston, Massachusetts, pp.362-366, 1978.

[10] Newell, A. and Simon, H.A., Human Problem Solving, Prentice-Hall, Englewood Cliffs, New Jersey, pp.2-3, 1972.

[11] Srinivasan, A., "Alternative Measures of System Effectiveness: Associations and Implications," MIS Quarterly, Vol. 9, No. 3, pp.243-253, 1985.