

EDUCATIONAL MANAGEMENT SCIENCE/OPERATIONS RESEARCH SOFTWARE: A SURVEY REVIEW

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요약 본 연구의 목적은 MS/OR 과목을 가르치는 교수들이 계량 소프트웨어 패키지들에 대해 가지고 있는 인식을 조사하기 위한 것이다. 본 연구는 미국 대학에 근무하고 있는 MS/OR 담당교수들에 대한 설문을 중심으로 이루어졌다. 연구결과, 현재 MS/OR 과목을 담당하고 있는 교수들은 기존의 소프트웨어 패키지들이 계산속도, 제공되는 모형의 종류, 다룰 수 있는 문제의 크기 그리고 알고리즘의 정확성 등에 만족하고 있는 것으로 나타났다. 그러나, 이들 교수들은 기존 패키지들의 'what-if' 분석 능력, 그래픽 기능, 모형 및 해(Solution)에 대한 설명기능, 출력물의 해독 용이성 그리고 사용의 용이성에 대해서는 불만을 가지고 있는 것으로 나타났다.

abstract The purpose of this research was to investigate instructors perceptions on the use of quantitative educational software packages in management science and operations research (MS/OR) related courses. The investigation was conducted using a questionnaire survey of MS/OR instructors at US universities. The authors found that instructors were satisfied in the use of existing MS/OR educational software packages to effectively support their teaching in terms of computational speed, number of models offered, size of problems, and accuracy of algorithms. However, many instructors were not satisfied with the tutoring capability of packages such as "what-if" analysis, graphics availability, explanation capacity, readability of output, and ease of use.

1. QUESTIONNAIRE DEVELOPMENT AND DATA COLLECTION

1.1 Questionnaire Development

To develop the questionnaire for this study, pertinent issues discussed by Yurkiewicz (1988) and by other previous researchers [Ashford and Daniel, 1988; Gunawardane, 1991; James, 1988; Janczyk and Beasley, 1988; Oberstone, 1986; Sharda, 1988; Turban and Erikson, 1985; Zanakis et al., 1991] were collected and used in the questionnaire design. Some of these issues included the number of models, problem size, algorithm accuracy, computation speed, and their functionality.

In addition, a literature review of articles from various fields of Management Information Systems identified

various features of what educational software packages could and should possess to be more effective and be user-judged as satisfactory software. A number of studies suggested scored means could be used to determine and measure user satisfaction [Bailey and Pearson, 1983; Baroudi, Olson, and Ives, 1986; Doll and Torkzadeh, 1988, 1991; Melone, 1990; Rushinek and Rushinek, 1986].

Based on this literature review, the authors developed a questionnaire that had five sections:

- (1)General information regarding instructors and courses;
- (2)Features of MS/OR ESPs instructors consider important in selecting an MS/OR ESP;
- (3)Instructors expected usefulness of MS/OR ESPs in their courses;
- (4)Instructors satisfaction with each feature of MS/OR ESPs in classroom use; and
- (5)Instructors perceived actual usefulness from using

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MS/OR ESPs in their courses.

(Note to reviewers: For reasons of brevity, the actual questionnaire will not be included in this paper but can be included if desired.) In all sections of the questionnaire excluding section one, each item has a five point Likert-type scale, where 1 = strongly agree; 2 = agree; 3 = neutral; 4 = disagree; 5 = strongly disagree. We compared the expectancy of instructors (in sections two and three) to actual usage of instructors (in sections four and five) of MS/OR ESPs.

The questionnaire items in sections two and three measure MS/OR instructors expected outcome or usefulness of several features of MS/OR ESPs. Most of these items are repeated in sections four and five to investigate MS/OR instructors perceived actual satisfaction and usefulness of pertinent features through classroom use.

1.2 Subject Sampling

The membership directories of INFORMS and Decision Science Institute were used to generate a sample group. The sample group was restricted to 700 members who define themselves as MS/OR or production/operations management (P/OM) specialists who teach management science and operations research type material in their P/OM course. The sample was restricted to US universities or colleges. To obtain a representative sample of the US MS/OR faculty population and to minimize possible sampling bias, a stratified sampling method were used. Basically, the 700 faculty were stratified by geographical location (i.e., groupings by North, South, East and West) and then randomly selected within each strata from the membership directories.

1.3 Data Collection

Out of 700 questionnaires sent, a total of 77 questionnaire sets were returned (11% return rate). In spite of the fact that prior research has stressed the need to incorporate more computer and software use in MS/OR courses since the 1980s [Chen, 1981; Render and Stair, 1981; Zahedi, 1985], the authors found that 17

out of 77 respondents (or about 22%) currently did not adopted any MS/OR ESP for their courses. The major reason given for not adopting a MS/OR ESP is that they believed MS/OR ESPs are not helpful or effective in supporting students understanding of MS/OR models.

Some respondents claim that MS/OR ESPs may actually deter students understanding of mechanics of MS/OR techniques.

Among the remaining 60 responses, instructors used STORM (9 responses), Management Scientist (8 responses), QSB (7 responses), AB:MS/OR (6 responses), AB:POM (6 responses), DSS for POM (6 responses), Lindo (6 responses), Excel (5 responses) and other (7 responses) individually different MS/OR ESPs.

This may indicate the greater field of selection that instructors have to choose from in the 1990s market of MS/OR software, since most of the prior studies on software list ten or less software systems in their findings.

2. DATA ANALYSIS

2.1 Description of Instructors and Courses

Bases on the instructor responses, faculty in this survey have been teaching the MS/OR courses for an average of 9 years. The decision to adopt MS/OR ESPs is made primarily by the course instructor(s) (90%). MS/OR ESPs are used primarily as teaching aids in the classroom or as tools for assignment completion. The majority of responding instructors have taught first level courses (86%) in a semester system (78%) which are required courses for business majors (95%) (Juniors (53.4%), Seniors (19.2%), and graduate students (15%)). More than one-third (35%) of the MS/OR instructors deemed it is not necessary to teach solution algorithms of MS/OR models while one half (51%) believed teaching solution algorithms to be necessary. Most instructors (87%) allocate less than 3 hours to train students in MS/OR ESP use. About 17% of instructors do not offer any training sessions to students while 37% of instructors have less than one hour of training session. This tends to indicate that most instructors consider the MS/OR ESPs are easily

Table 1 Models Instructors Want to Have in MS/OR Educational Software Packages(n=60)

Feature	Ferq (%)
Linear Programming	59 (98.3%)
Forecasting Models	32 (53.3%)
CPM/PERT/Project Management	27 (45.0%)
Materials Requirement Planning	24 (40.0%)
Integer Program	23 (38.3%)
Queuing Theory	20 (33.3%)
Inventory Model	19 (31.6%)
Transportation/Assignment Model	18 (30.0%)
Goal Programming	17 (28.3%)
Simulation	15 (25.0%)
Quality Assurance/Control	15 (25.0%)
Decision Theory	12 (20.0%)
Facility Layout/Location	10 (16.6%)
Line Balancing	7 (11.6%)
AggregatePlanning	6 (10.0%)
Utility Models	1 (1.6%)
Analytic Hierarchical Programming	1 (1.6%)
Non-LinearProgramming	1 (1.6%)
DynamicProgramming	1 (1.6%)

assimilated by students.

Table 1 lists the quantitative models that instructors want included in MS/OR ESPs. Linear programming and operations management topics such as Forecasting,

CPM/PERT/Project Management were most frequently mentioned MS/OR ESP models. One interesting result is that a smaller number of instructors expect to have simulation models in MS/OR ESPs even though simulation models are usually considered an important MS/OR technique [James, 1988; Gunawardane, 1991].

One reason for this situation may be that many instructors believe that simulation techniques require too much space to put into the PC-based MS/OR ESPs.

2.2 MS/OR ESP Features Instructors Consider Important

Selecting the appropriate MS/OR ESP is important because a poor selection could cause excessive time demands, student confusion, or inappropriate course focus [Turban and Erikson, 1985]. Previous studies regarding the evaluation of MS/OR ESPs [Ashford and

Table 2 Scored Criteria Instructors Use to Select MS/OR Educational Software Packages (n = 60)

Rank*	Features	Mean Score
1	Accuracy of algorithm	1.35
2	Ease of operating use	1.36
3	Ease of entering & editing data by a user	1.57
4	Screen & printed output format	1.67
5	Purchase price	1.85
6	Ease in changing formula & data for "what-if" analysis	1.85
7	Input error checking by the software package	1.99
8	Quality of the textbook accompanied	2.00
9	Readability of documents in package or manual	2.02
10	Graphic output if needed	2.04
11	Availability of "what-if" analysis function	2.13
12	Ease of installation	2.13
13	Explanation (formulation, solution process, output)	2.15
14	Number of models offered in a package	2.15
15	On-line help function of software use	2.25
16	Same terminology in package & textbook	2.28
17	Size of problems a package can handle	2.32
18	Vendor's prompt service & support	2.35
19	Availability of sample problems in package	2.35
20	Experience of using that package	2.58
21	Computation speed	2.63
22	Software package authors' reputation	3.39

(*)Ranks based on mean score.

Daniel, 1986; Janczyk and Beasley, 1988; Oberstone, 1986; Sharda, 1988; Turban and Erikson, 1985; Yurkiewicz, 1988; Zanakis et al., 1991] focused, among other things, on algorithm accuracy, computational speed, number of models offered, and problem size of each model. Survey results showed that MS/OR instructors use the selection criteria of algorithm accuracy as the most important, followed by ease of operating use and ease of entering & editing data by user. The ranked importance of selection criteria are given in Table 2.

The evaluation criteria MS/OR instructors use shown in Table 2 are different from the evaluation criteria listed in previous studies. For example, instructors no longer consider the size of each model MS/OR ESP can handle, the number of models offered, or the computational speed as significant enough to be ranked in the top 10 of selection criteria. The reason for this may be that instructors believe that most of the MS/OR

ESPs can handle textbook problems relatively well considering today's computers. Instead, instructors emphasized algorithm accuracy, ease of use, output format, readability, graphics, and "what-if" analysis capabilities as the significant issues for effective teaching (or learning) of MS/OR models.

One important finding is that many responding instructors want to have "what-if" analysis capability or, at least, the capability of changing formulas and data for "what-if" analysis in MS/OR ESPs. The reason may be that those instructors believe that "what-if" analysis is one important step in implementing the MS/OR model solutions to solve the real world problems as mentioned in previous studies [Gunawardane, 1991] but not well implemented in the MS/OR ESPs.

2.3 MS/OR ESP Usefulness Expectations of Instructors

In this survey section, based on the collection of prior research studies, eight desired educational outcomes are examined to investigate the expected outcomes MS/OR instructors anticipate from using MS/OR ESPs. These eight are listed as Outcomes in Table 3.

In general, instructors expect to see that MS/OR ESPs provide: efficient model solutions (mean = 1.68), useful in teaching MS/OR courses (mean = 1.80), and correct model solutions (mean = 1.89). Also, instructors expect that using MS/OR ESPs will increase students' interest in MS/OR courses (mean = 2.19) and allow students to concentrate on model formulation (mean = 2.23) rather than on solution procedures.

Comparing these mean values with those of other items, it seems that most instructors perceive the main objectives of using a MS/OR ESP are obtaining model solutions efficiently and accurately rather than helping the students to understand MS/OR techniques. For example, instructors expected that MS/OR ESPs will help students when they have problems in

Table 3 Instructors' Perception Scores on Expected Outcome and Actual Outcome of the MS/OR Educational Software Package

Outcome	Mean		Mean Diff.	Mean* Div.	Std T	p
	Expected	Actual				
1 support student in understanding MS/OR techniques	2.86	2.49	0.373	1.081	2.649	0.0104
2 demonstrate solution steps accurately and effectively	2.94	2.77	0.169	1.262	1.032	0.3064
3 allows students to concentrate on model formulation abilities	2.23	2.13	0.102	0.781	1.000	0.3215
4 help student if they have problems in understanding models	2.77	2.72	0.052	1.016	0.388	0.6997
5 increase students interest in MS/OR course	2.19	2.14	0.051	0.680	0.574	0.5681
6 useful in teaching MS/OR course	1.80	1.94	-0.136	0.601	-1.734	0.0882
7 provide model solutions quickly	1.68	1.73	-0.051	0.628	-0.622	0.5362
8 provide accurate model solutions	1.89	1.92	-0.034	0.982	-0.265	0.7918

(*) Mean Difference = Mean Score of Expected Usefulness - Mean Score of Perceived Actual Usefulness.

understanding MS/OR models (mean = 2.77), support student understanding of MS/OR techniques (mean = 2.86), and demonstrate model solution steps effectively (mean = 2.94).

2.4 Perceived Actual Usefulness Instructors Have from MS/OR ESP Use

Another objective of this survey section is to ascertain whether instructors achieve the expected

outcomes using MS/OR ESPs in teaching their courses. As can be seen in Table 3, the outcomes (i.e., 1 through 5) related to understanding and interest in the subject consistently had higher mean expected scores than mean actual scores. This may indicate that instructor expectations are not being met as well as they should in these educational outcome areas. The other three outcomes (i.e., 6 through 8) focusing on computational accuracy and speed have greater mean actual scores than mean expected scores. This may indicate that the sample ESPs are doing a more than adequate job in these educational areas.

The most useful experience MS/OR ESPs instructors actually have is in providing solutions quickly for the students (mean = 1.73, from Table 3). By comparing the mean scores via a simple t-test ($p=0.01$) of expected and perceived actual usefulness for all eight outcomes, we found that there are no statistically significant differences. In other words, MS/OR instructors responded statistically that they achieve what they expect to achieve from the MS/OR ESPs.

Despite the lack of statistical significance, the differences in the mean scores show that MS/OR ESPs could be used to help students understand MS/OR models more effectively by supporting students in many different ways such as demonstrating solution steps accurately and effectively, allowing students to concentrate on model formulation abilities, or increasing students interest in MS/OR courses.

2.5 Satisfaction of Various MS/OR ESP Features

In this section of the survey, the instructors are asked to report level of satisfaction with the features of

MS/OR ESPs they adopted and used. The most satisfactory feature of MS/OR ESPs cited is the accuracy of the algorithm (mean = 1.87) followed by the computational speed (mean = 1.90) and ease of installation (mean = 1.99) as shown in Table 4.

Instructors also seemed satisfied with the number of models offered in MS/OR ESPs (mean = 2.09) and the size of problems MS/OR ESPs can handle (mean = 2.23). This result is different from what Zanakis et. al. [1991] who suggested the MS/OR ESPs had too many

models in a small space and that it would be better to have fewer models with more in depth coverage of each model.

In regards to many features of MS/OR ESPs, there are some interesting differences between expected and perceived actual instructor satisfaction as shown in Table 5. There were some features that are not statistically significantly different. Those features included the size of problems a package can handle, the number of models offered in a package, the same terminology used in package and textbook, and ease of installation. This means that the instructors scores indicate that they are satisfied with those features as expected when using their MS/OR ESPs.

The features that instructors find most unsatisfactory in the sample ESPs included all those listed on Table 5, ranked in order by their level of their Mean Difference score. All of these features have the widest gap between expected and perceived actual satisfaction (Mean Difference

score is larger than 1.0). We believe that graphic output capability as well as ease of use of MS/OR ESPs are expected to be much improved in the near future due to the popularity of the Windows interface on PC in recent years. It may be a transition period from DOS-based MS/OR ESPs to Windows-based MS/OR ESPs which will have superior graphics and easy to use features.

As far as the readability of documents is concerned, they could be much improved if MS/OR ESP developers design those packages to help end users understand

Table 5. Those Features that are Significantly Different Between Expected and Perceive Actual Satisfaction of MS/OR Educational Software Package (p=0.01).

Rank	Features
1	Graphic output (if needed)
2	Ease in changing formula & data for "what-if" analysis
3	Readability of documents in package or manual
4	Explanation (formulation, solution process, output)
5	On-line help function of software use
6	Ease of operating method
7	Vendor's prompt service & support
8	Availability of "what-if" analysis function
9	Input error checking by the software package
10	Ease of entering & editing data by a user
11	Screen & printed output format
12	Accuracy of algorithm

(*)Ranks based on mean score.

screen display or printed output more effectively and efficiently. To achieve this, it is recommended that a more thorough user requirement analysis be performed for each MS/OR model.

The explanation capability that many instructors wanted from MS/OR ESPs has been one of the most important issues in machine learning paradigm [Schank and Leake, 1990; Ye and Johnson, 1995]. An effective development approach for adding the explanation capability to MS/OR ESPs was suggested by Lee and Kim [1995]. They suggested a method of providing necessary explanations for each solution step of an algorithm by comparing the machine generated correct answer with the student's answer. Also, Lee and Kim [1992] showed that using an explanation oriented solution algorithm helps students understand MS/OR models better than using a calculation efficiency oriented solution algorithm. Adding better explanation capability to the currently available MS/OR ESPs may be an important step to move from the computation oriented MS/OR ESPs to the tutoring (learning) oriented MS/OR ESPs.

3. DISCUSSION OF FINDINGS

Table 4. Instructors Satisfaction Scores on Each Feature of the MS/OR Educational Software Package (n = 60)

Rank	Features	Mean Score
1	Accuracy of algorithm	1.87
2	Computation speed	1.90
3	Ease of installation	1.99
4	Number of models offered in a package	2.09
5	Ease of operating method	2.23
6	Size of problems a package can handle	2.23
7	Ease of entering & editing data by a user	2.27
8	Screen & printed output format	2.38
9	Same terminology in package & textbook	2.62
10	Purchase price	2.62
11	Input error checking by the software package	2.79
12	Availability of "what-if" analysis function	2.99
13	Availability of sample problems in package	3.03
14	Readability of documentation (in package or manual)	3.17
15	Ease in changing formula & data for "what-if" analysis	3.19
16	Vendor's prompt service & support	3.21
17	Explanation (formulation, solution process, output)	3.28
18	On-line help function of software use	3.32
19	Graphic output (if needed)	3.62

(*)Ranks based on mean score.

Based on this survey, it appears that many instructors consider the MS/OR ESPs useful in teaching MS/OR courses. Even though not statistically significant, many MS/OR instructors believe that MS/OR ESPs are more useful than expected in supporting students in understanding MS/OR techniques. However, it is also observed that the longer the instructors have taught MS/OR courses, the less they think the MS/OR ESPs are useful. One explanation may be that some instructors failed to adjust their courses to use MS/OR ESPs effectively, as a recent study [Leidner and Jarvenpaa, 1995] reported. This means that without changing the teaching and learning process, computer systems used in classrooms may do little but speed up ineffective processes and methods of teaching. It seems that without proper adjustment of teaching materials or methods, using MS/OR ESPs will not be as effective as expected.

It was observed in this survey that the usefulness of MS/OR ESPs is the main factor for adopting MS/OR ESPs rather than ease of use features indicated by the fact that many instructors use MS/OR ESPs even

though they are not satisfied with many of the ease of use features. The reason may be, as suggested by Davis [1989], usefulness of information technology seemed to have a significantly greater correlation with usage behavior than did ease of use.

Another observation is that even though many instructors consider the MS/OR ESPs effective tools in teaching and efficient tools in generating model solutions, they want to have more tutoring capacity from MS/OR ESPs such as explanation, student support in problem solving, and "what-if" analysis capabilities.

The lack of these features is the main reason noted by some instructors for not adopting any MS/OR ESPs (22% which is 17 out of 77 responses). It does not necessarily mean that MS/OR ESPs should be developed as a fully functional intelligent tutoring system as the machine learning researchers suggest. Rather, it implies that the MS/OR ESPs need to have more tutoring capability in addition to reducing the math burden on students.

4. CONCLUSION

This survey describes the perceptions of MS/OR instructors regarding the selection criteria, expected and actual usefulness, and expected and actual satisfaction on the educational software packages in their MS/OR or P/OM courses. The results of this survey have revealed possible educational software features in MS/OR packages where improvement could take place.

The findings of this study could be used as a guideline for designing and developing more user satisfactory MS/OR educational software packages.

In summary, this survey discovered "what" features need improvement in MS/OR packages. Future research is needed to investigate "how" to improve each feature in the MS/OR software packages.

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주요 관심분야는 최종사용자 전산,

ERP, 지식경영, BPR 등