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## **ABSTRACT**

### **DECISION MAKING BASED ON QUANTITATIVE AND QUALITATIVE EVALUATIONS**

by  
**Rohan A. Pandit**

This study emphasizes mainly on the influence of evaluations, both qualitative and quantitative, on decision making for many occasions that occur in business and technically oriented settings. Decisions made with a certain fuzzy as well as technical behavior are structured by means of computer-assisted decision-making tools. Decision support tools assist decision makers in making crucial decisions. For instance the tool that has been designed for the purpose of this research will be used for selecting capital-intensive products. It is also intended to prove that with the help of decision support systems decision makers could make decisions by reducing fuzzy decision behavior about capital investments in organizational systems. Such tools consider more than one criterion in making a decision. The criteria for decision-making will range from the attributes of the system itself to the cost of the system. For each system under consideration for selection, each attribute will be analyzed and rated. Then a cumulative account of all the attributes for each vendor is brought together as a set. Though this set is produced by each decision maker there is little correlation between his decisions and the evaluation of the product. A product's quantitative evaluation may warrant of a different kind of decision than a qualitative evaluation.

An evaluation of a system leads to a decision. However when a decision is the one of selection, as is quite often the case, quantitative and qualitative evaluations may be done. Quantitative evaluations generally are performed based on statistical analysis of the system under consideration. A quantitative evaluation may be based also on algorithms designed for specific scenarios. On the other hand a qualitative evaluation may take place in settings that deal with a single system that must be evaluated and it's evaluation recorded in language specific descriptive terms. This study discusses how decisions can be made using qualitative and quantitative evaluations for the object or situation under consideration.

**DECISION MAKING BASED ON QUANTITATIVE AND  
QUALITATIVE EVALUATIONS**

by  
**Rohan A. Pandit**

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**APPROVAL PAGE**

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To my beloved family and friends

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## GLOSSARY

**Eta** Index of correlation not limited to linear relationships

**F-test** A test of significance employed to judge the tenability of the null hypothesis of no relation between two or more variables, or of no difference between two variables.

**Likert Scale**

**null hypothesis** A null hypothesis helps to decide between (1) believing that a relationship between two (or more) variables exists in the population from which sample data are drawn and (2) believing that no such relationship exists in the population from which sample data are drawn.

**one-way ANOVA** one-way analysis of variance is comparing variances—the variances among means is compared with the variance within conditions in order to find out how far apart the means are on average.

**SS** Sum of Squares of values of any given variable

**t-test** A test of significance employed to judge the tenability of the null hypothesis of no relation between two variables.

**two-way ANOVA** two-way analysis of variance is similar to one-way analysis of variance in addition that interaction effects are taken into consideration.

## **CHAPTER 1**

### **A FOUNDATION FOR USING EVALUATIONS**

A group used to make decisions on a particular topic of discussion or issue can use various group decision support systems. Group decision support systems are crucial when groups need communications, computer and decision support process or structures [9]. Various tasks are supported by group decision support systems. Group decision support tools are available for a group involved in discussions, communication, planning, design and development. Simple asynchronous tools such as instant messaging system is used in workplaces for making decisions with the support of another group members when they are distributed over time and space. Instances of making decision for selecting naming conventions during a software installation, asking for assistance on a certain task etc. can be made by a junior developer by messaging a senior colleague. Such scenarios involve communication, however, other tasks where a solution must be selected for it to be implemented fall critically under McGrath's typology or task circumplex [22].

#### **1.1 The Importance of the Use of Evaluations**

The task circumplex indicates that arriving at a solution involves starting with an idea. This constitutes planning for a possible solution. Many such ideas and consequent plans may be conceptualized. The most crucial phase of the process of arriving at a solution consists of choosing the alternative. This is an intellective task and it forms the basis of the discussion on

quantitative and qualitative evaluations. Since this may also turn out to be fuzzy in nature it will call for multi-criteria decision-making [12] and most crucially when capital investment projects must be evaluated. One such example is the choosing of an academic database, which costs millions of dollars. Much research has been done for the effectiveness of solutions for such problems as selecting the optimum database for a given query based on the decision about which database, from a number of given databases, should be chosen for that query. Since this is very specific to a query a similar principle can be applied to a collection of queries and estimates can be made about cumulative costs of retrieval.

This, done for all the databases, in our context ‘solution’ yields the appropriate database. Another approach to selecting solutions (academic databases) has been considered on a yet unpublished research-work, which takes into account gross rating values of a decision-maker. Importance is also given to the attributes of a database by each decision maker and each attribute is rated. Following this various mathematical calculations are conducted by the software on these ratings and a final decision vector (a one dimensional matrix) consisting of the cumulative effect of the decision makers ratings (made earlier) is presented. The database that yields the highest point value or a numeric value must be chosen as the one most appropriate for the selection problem under consideration. This takes into account the fuzziness [15] of each decision maker through a quantitative approach presented as a case study of quantitative evaluation for making a decision.

## 1.2 Quantitative Evaluations for Decision Making

Qualitative evaluations of possible solutions for decisions to be made on them may be done as executive summaries or by recording non-numeric and language specific inputs or opinions about the systems. This can also follow the pattern of questionnaires, qualitative-quantitative evaluation scales such as the Likert scale, which translates qualitative inputs to quantitative ratings [26] when many users for a single system are involved. On the other hand executive summaries or self-recorded diaries [26] would be more appropriate for a single user independently evaluating the system.

Thus choosing alternatives for ultimately deciding which one must be chosen leads to negotiating solutions [22]. This is also a key issue in the task circumplex in that negotiating the right solution makes the concluding result a successful or unsuccessful one. Hence in this phase occurs cognitive conflict and it must lead to resolution of the conflict. This is very well done by negotiating into the solution (qualitative or quantitative evaluation) that best fits the given problem. Not much is discussed here, about which solution must be negotiated into. This must be done crucially after many alternatives are chosen qualitatively or quantitatively. It can therefore be seen that the earlier mentioned intellective task of arriving at the right solution is done by approaching the problem quantitatively or qualitatively.

A negotiated solution is finally put to execution. This is also crucial but it is seen as less strategic than the previous domains of the problem of decision-making. This is because

execution consists of less conflict than arriving at the right solution. However this may not mean that no importance be given to the execution since the final product or the result in general depends on execution. Besides, the result meeting the original idea spells success and so due importance must be given to execution.

## CHAPTER 2

### QUANTITATIVE EVALUATIONS FOR SOFTWARE SYSTEMS

#### 2.1 Using Custom Algorithms for Software Evaluation

This is the first section on quantitative evaluations and the use of quantitative evaluations has been discussed before. On this section it has been discussed of how to use algorithms to analyze systems. The use of algorithms is done in programming and solution formulation. Algorithms may be used in places having a structured solution. The use of algorithms may not be warranted in places where the problem is weakly structured and the possible solution is very subjective. However when it is intended to remove subjectivity from the ultimate decisions that must be taken they can be quantified by the use of algorithms. The concept of usability and functionality [13] is particularly taken into account here because the sample evaluations illustrated here are that of the user-interface of software products.

In the context of discussion algorithms are used to analyze systems and therefore algorithms do not contain programming syntax but do contain logic for evaluating the system. The logic used in the algorithm must be formulated using the attributes of the system. This means that system features, costs, end user satisfaction etc must be put down as attributes and must be analyzed quantitatively to enable a final numeric output to enable making a decision in favor of or against the choice of the solution or the system. Therefore it is crucial to formulate the decision algorithm correctly and in logical sense. The algorithm may begin by identifying

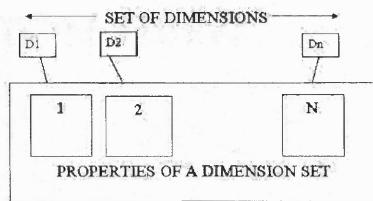
the systems various features. Thereafter if many systems are under consideration for a selection task, then it must be analyzed whether the system has the feature or not. It must go through a certain order of logic for the entire system. There may be a system lacking a feature and hence there should be no evaluation for such a feature. Does this mean that the system will lose on the numeric value it gains from not having the feature? It may or may not in comparison to the other systems. There could be another system, which carries the feature, which may not evaluate very well on the given scale. The system could have done a very low numeric value on the attribute. Therefore not carrying a feature may affect the evaluation of the system.

It is shown here how two softwares were evaluated using algorithms specific to the generality of those systems. It means that when certain similar systems must be evaluated there must be a common set of criteria that each one must be evaluated for. The criteria have been set for the systems under consideration. The evaluations are based on the responses that one would get as answers to the questions in the algorithms. The formulation of question algorithms is based on the said set of criteria, which are decided before the evaluation is started. The results have been tabulated on spreadsheets for ease of review when needed. For this the following figure 1 is used as my basis to start the evaluation.

A dimension has the set of properties. To start evaluation the following question must be asked. Does the software have an element that reflects this dimension? If yes then evaluate it quantitatively or qualitatively depending on the dimension. Then a dimension is evaluated

evaluated with respect to the properties set. The question asked is whether the dimension has this property? If yes then evaluate it quantitatively or qualitatively.

This forms the starting point of the evaluation. Questions shall be asked regarding the dimensions and properties of the software. They lead to the various question algorithms and the final justification of which software must be chosen.



**Figure 1 Dimensions and Properties**

The softwares under evaluation are product TB and product DF. Both softwares are information management softwares and the use of these is generally seen in document personal management and organization of related material that is normally related however is not brought together by existing software systems. The softwares were evaluated for the user-interface of each. The various criteria used were the user-interface dimension and the properties of the dimensions. The softwares were not evaluated for performance or any other underlying features. The following primary questions were asked for the evaluation of the software. Do the set of properties of dimension sets i.e. for e.g. Foundation Factors, Ease of

learning etc. have the same? If yes how well do they satisfy, how does the software satisfy the dimension? and so on. Here is a set of dimensions and properties of user-interfaces [30].

With  $n=6$ (index for dimensions) and  $N=5$ (properties) where

D1=Foundation Factors(8 elements)

D2=Ease of learning (10 elements)

D3=Sense of control(13 elements)

D4=Effectiveness(9 elements)

D5=Psychological and Sociological (13 elements)

D6=Administrative(10 elements)

Values for N are as follows

1=Perception

2=Measurability

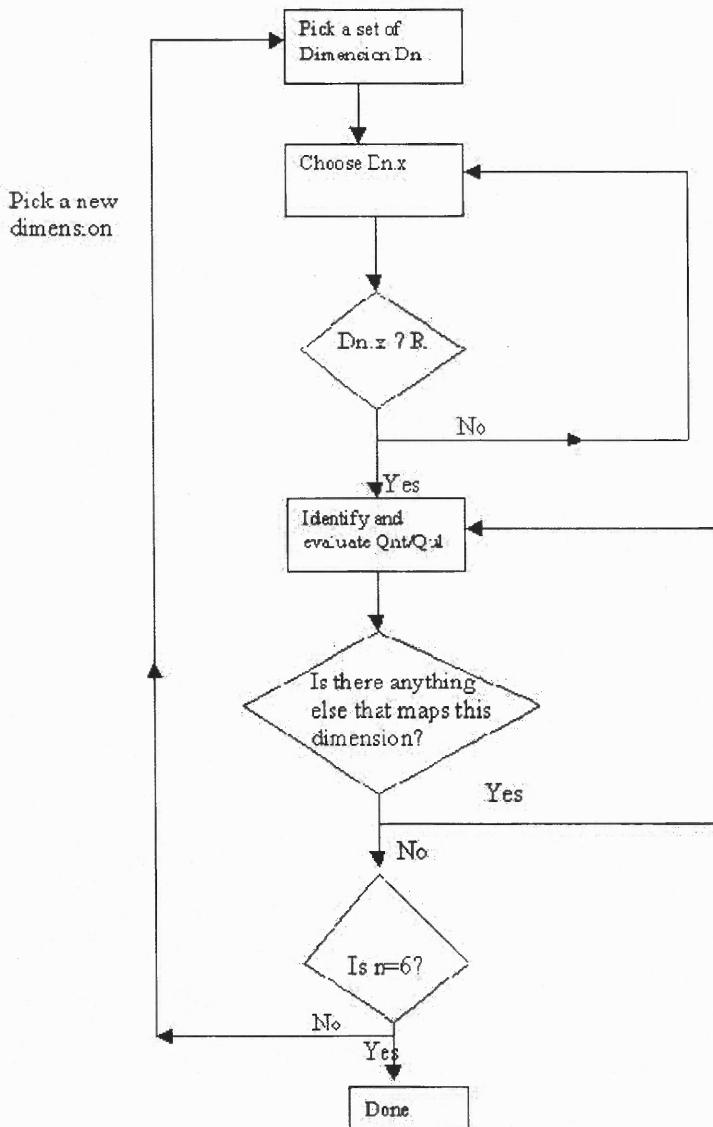
3=Orthogonality

4=Sensitive

5=Evaluative

The following structured question forms the building block of this section in that this identifies the dimension in the software. Does the software have  $D_n$ (where  $n$  can be from 1 to 6 and hence D1 to D6 are Foundation Factors, Understanding etc. in order). D1 through D6 describe the dimension sets. Hence it must be asked if the software does have a  $D_{n,x}$ (where  $D_{n,x}$  is any element of the dimension element of the dimension set such as Guidance in

Foundation Factors) for each of the elements of the set. Hence one must pick a D<sub>n</sub> and start evaluation at D<sub>n.x</sub>. It will be asked what identifies the D<sub>n.x</sub>? Finally notes shall be written on how well the dimension is exemplified by, say a certain thing on the software. This means that one must find the object or feature in the software that reflects the dimension. D<sub>n.x</sub> ? R means the following: Does such a dimension called D<sub>n.x</sub> exist. R is the result in Yes or No.



**Figure 2** Algorithm for evaluating the dimensions of a software

The final results are tabulated as follows. The dimensions identified in the software are qualitatively or quantitatively evaluated and may be placed in the table shown below. The evaluations taking place are purely subjective and they form the basis of choosing the software among the two that are available for this evaluation.

**Table 1** Evaluation for interface dimensions

| Dimension set name | Dn.x  | Dn.x ? R in Y/N | Element in s/w that maps the dimension | Quantitative/Qualitative evaluation |
|--------------------|-------|-----------------|--|-------------------------------------|
| -----              | ----- | Y/N             | -----                                  | -----                               |

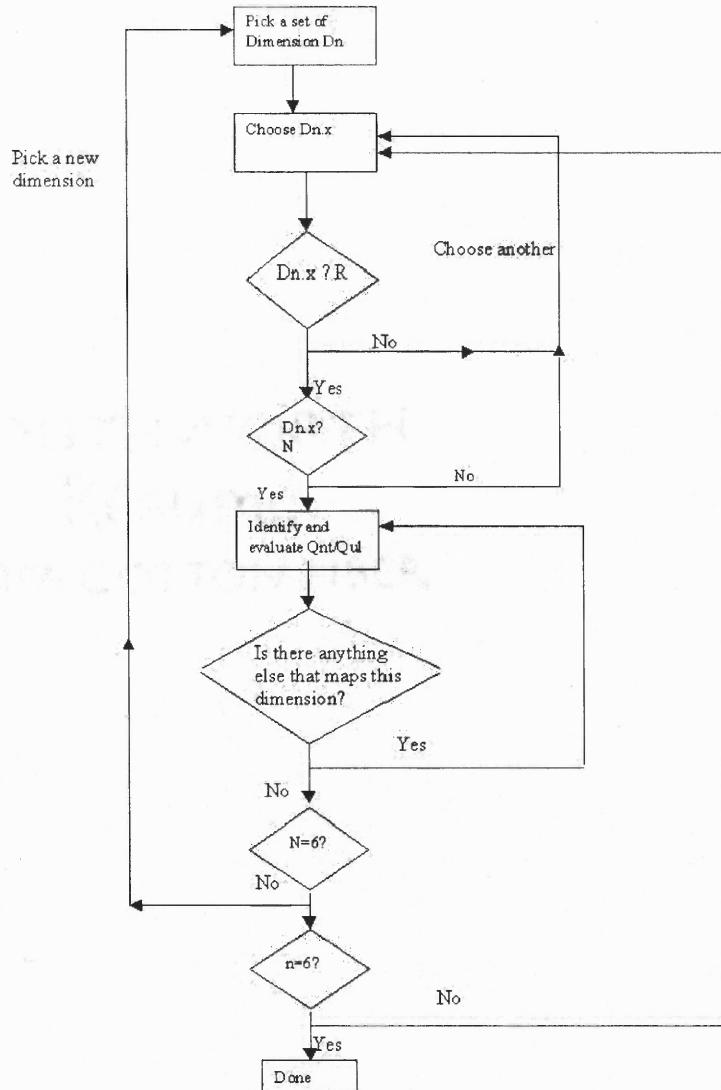
Dotted lines in the cells indicate the appropriate subject matter filled in the table. An excel worksheet or other such spreadsheet software is recommended to be used to record the results of the evaluations of the subject. For this evaluation a single subject was chosen. The subject evaluated the software and recorded his results in an large worksheet.

To evaluate whether the 'Dimension Set' satisfies its 'Properties Set' the properties set is applied to each Dn.x. Hence what must be done is Dn.x ? N i.e ask the following question: Does Dn.x have N(i.e. the property for e.g. Perceptive, Measureability). The more Yes's it gets the better is the software and also the quality or quantity of Dn.x. This is a crucial factor because not only is the presence or absence of a feature is being tested but it's qualitative or quantitative value, whichever is appropriate, is also evaluated. Hence the biasness towards the software that has more features is eliminated in that it may evaluate poorly on it's qualitative or quantitative value. The results will be tabulated in the following table:

**Table 2** Evaluation for element mapping a dimension

| Dimension set name | Dn.x | Dn.x ? R in Y/N | Element in s/w that maps the dimension | Dn.x ? N in Y/N | Quantitative/Qualitative evaluation |
|--------------------|------|-----------------|--|-----------------|-------------------------------------|
|                    | ---- | Y/N             | -----                                  |                 | -----                               |

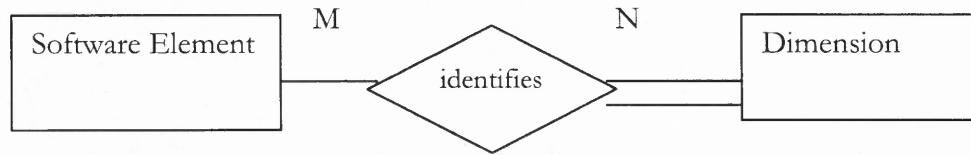
Thus the meaning of this final algorithm translates to the following questions. What is the feature of the software that identifies Dn.x and whether it does satisfy N(property) or not? If it does then what are its qualitative and quantitative properties? In detail the algorithm is as follows. First a dimension set is picked. This means that a dimension set is chosen from D1 to D6 called Foundation Factors, Ease of learning, Sense of control, Effectiveness, Psychological and Sociological, Administrative. Then a dimensions element must be chosen. The existence is then verified. If it does have the element then the next step is to verify if the property for that dimension element exists and if it does then it must be evaluated quantitatively or qualitatively. This must be repeated for each property(Perception, Measurability, Orthogonality, Sensitive, Evaluative) for the dimension under analysis. The next step is to go to the next dimension and follow the algorithm for it. This is repeated until all the dimensions are evaluated. The algorithm is as follows:



**Figure 3** Algorithm for evaluation of the element mapping a dimension

The following calculation is based on only one element in the software identifying one dimension. The first algorithm would yield  $8+10+13+9+13+10 = 63$  results. The second algorithm would yield  $6 * (8+10+13+9+13+10) = 378$  results

However the software element– dimension relationship is M:N. Shown as follows



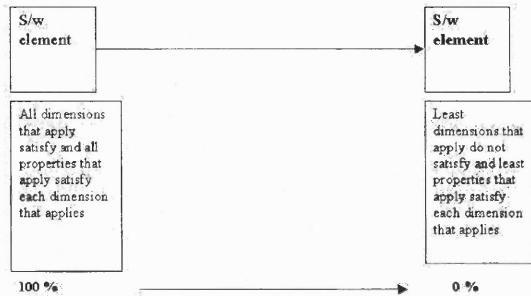
**Figure 4** Relationship between a software element and dimension

This makes the evaluation even more complex where a software element based table must be made to see how “EFFECTIVE” the software is. The more there are Y check marks and better the Quantity or Quality of evaluation better is the software.

**Table 3** Evaluation of each element mapping a dimension for a property

| Software Element 1 | Dimension set name | Dn.x  | Dn.x ? R in Y/N | Property exists ? R in Y/N | Element in software that maps the dimension |
|--------------------|--------------------|-------|-----------------|----------------------------|---|
| -----              | -----              | ----- | Y/N             | Y/N                        | -----                                       |
| Software Element 2 | Dimension set name | Dn.x  | Dn.x ? R in Y/N | Property exists ? R in Y/N | Element in s/w that maps the dimension      |

Thus the ‘effectiveness’ evaluation is based on the following graphic:



**Figure 5** The effectiveness evaluation of a software

The above figure shows that for a software element if all dimensions that apply satisfy and all properties that apply satisfy each dimension that applies then the effectiveness of the software is a one hundred percent. Opposite to this when, for that software element, if the least number of dimensions that apply do not satisfy and the least number of properties that apply and do not satisfy each dimension that applies, the software is considered most ineffective or not useful. Similar to the effectiveness the software may be rated differently in terms of what is being measured. This means that the scale of 100 to 0 can be used for an overall effect of the system like overall efficiency, it's time efficiency, security etc just like the effectiveness which was measured in this study. Each software being evaluated may rate any amount(on the scale of 100 to 0 percent) on the effectiveness or the system feature under evaluation. The results of evaluation of the softwares has been shown in the tables below.

**Table 4** The evaluation table for software product TB

| Dimension Set (Dn) (Dn.x)        | Dimension Element              | Dn.x?R (Y/N) | Element in s/w that maps the dimension | Quantitative/Qualitative Evaluation   |
|----------------------------------|--------------------------------|--------------|--|---|
| Understanding & Ease of Learning |                                |              |  |   |
|                                  | Guidance                       | Y            | Help menus                             | The software as well as the dialogue boxes guide the user well in his task, and includes many references and examples.                |
|                                  | Informativeness                | Y            | Pull down menus, dynamic text.         | The help as well as the dialogue boxes give ample information such as to do a specific function, as well as learn about the software. |
|                                  | Conciseness and brevity        | Y            | Menus                                  | It is very concise in giving information and gives the user exactly what he asks for  |
|                                  | Clarity and simplicity         | Y            |  | The interface is very simple and easy to use.   |
|                                  |                                |              |  | Though the material offered is a bit too much.  |
|                                  | Comprehension                  | N            |  | The system is a bit difficult to comprehend for a first time user as the options and menus offer a complex set of functions.          |
|                                  | Segmentation and Decomposition | Y            |  | The system is very well decomposed into subdivisions, so that the user can only work on what he chooses.                              |
|                                  | Consistency                    | Y            |  | The system is consistent, with all the messages appearing consistently in the same place, as with all the dialogue boxes.             |
|                                  | Retention                      | Y            |  | The interface interacts well with the user and makes him well acquainted with the system commands.                                    |

From the study of these two softwares by the one subject that was selected to evaluate the systems, it should concluded that the first software, product TB, evaluated quantitatively as well as qualitatively better than the other software, product DF.

The software product DF was evaluated in the same manner. The product did not evaluate as well as the first software from the quantitative(Yes's and No's for the existence of dimensions) and qualitative(subjective description) evaluations. The evaluation has not been shown. Following is a transcript of what the user thought about the two systems.

"Using the software product TB, is just like using your natural brain and no effort must be really made to understand the inner workings of the menus and contexts that go with the software. It is striking that TB is for users who have some basic experience with application software such as the MS Word, MS Excel. For more comprehensive users of the computer, those who use the web extensively in conjunction with various other programs and files on his/her computer is more likely to use this software.

The software product DF is more of an information organization product related to business databases/commercial applications. TB taps the potential of the fundamental aspect of the human cognizance that root of each thought is a "Strategic" choice and that all proceeds from thereon. The rest is details and use of tools."

The overall score of the Yes's to the satisfaction of the user(in this case it is the subject) with respect to the completeness of the software in relation to dimension is 8:6 in favor of TB. The quantitative and qualitative analysis also show preference towards TB and that makes it doubly sure that the TB must be made "STANDARD" for the use of business practice tools i.e. for presentation, information organization and retrieval. It is truly of great help when you have your TB sitting right in front of you on your desktop.

The evaluation with respect to the properties of dimensions would yield better and more comprehensive results for TB conclusively because, in the first place, TB has more dimensions and secondly, Algorithm 2 which helps in evaluation of the software with respect to the satisfaction condition of properties being applicable set for a dimension set, will have an

advantage for TB. Hence it is not necessary to apply Algorithm 2 avoiding another about 60 results on the worksheet. The effectiveness of TB software could be about 85% approximately with the help of the spreadsheet evaluation.

## 2.2 User Satisfaction Measurement

The measuring of user satisfaction is crucial to the evaluation of the system. The measure of user satisfaction enables the choice of the system or solution. A system which rates poorly on user satisfaction will not make a good choice for the decision options under consideration. The systems user satisfaction is also a measure of quantitative evaluation of the system in that the users rate the system and consequently enable the ultimate judgment of whether the choice of the system must be made or not. It must be considered that the system that evaluates very highly on user satisfaction is mostly likely to succeed. If however the system is not a end user system it may have to be evaluated differently using methods suggested in the other sections of this study. User satisfaction is very qualitative in terms of user inputs about the system. However methods have been devised to quantify such user inputs about the system. One especially interesting study on user satisfaction is done on [3]. It explains how user satisfaction may be quantified.

Referring to a model of analysis in the study it has been said "This model suggests that satisfaction is the sum of one's positive and negative reactions to a set of factors. An individual's feelings must, in this model, be placed somewhere between a 'most negative' and a "most positive" reaction." [3]. It can be commented about the method of defining/computing

user satisfaction and what's missing in this paper for deciding whether the system is usable for a the group that was tested. By this it is meant whether a system should be called usable or not considering the user satisfaction of each user that was tested. User participation, user involvement and user attitude was studied in a paper by Henri Barki and Jon Hartwick [4]. This is an important study because these serve as key variables in successful information systems development.

The user satisfaction was defined as the  $\Sigma(\text{rating} * \text{weight})$  using proper indexing for the rating, the factor under consideration and individual. It has been said that the individuals feelings must be placed between most negative and most positive however nothing has been said of what would happen to "overall user satisfaction".  $S_i$  - has been defined however it remains to be seen whether or not putting that system into use for the target population would be satisfactory. For this it is suggested to use "pessimistic weighing" for the importance value  $W_{ij}$  (the importance of factor  $j$  to individual  $i$ ). The reactions  $R_{ij}$  (the reaction to factor  $j$  by individual  $i$ ) should also be "pessimistically weighed". Pessimistic weighing means that the average of the minimum of reaction-values / importance-values given by all individuals and the average of reaction-values / importance-values given by all individuals. This is same as saying the following mathematically

for reaction:

$$1/2[ \min(R_{1j}, R_{2j}, R_{3j}, \dots) + 1/\text{total\#of\_individuals}(R_{1j} + R_{2j} + R_{3j}, \dots) ]$$

and similarly importance:

$$1/2[ \min(W_{1j}, W_{2j}, W_{3j}, \dots) + 1/\text{total\#of\_individuals}(W_{1j} + W_{2j} + W_{3j} + \dots) ]$$

In simple words, by this we get the worst-case scenario of a reaction to a particular aspect of the system. Finally we can use pessimistic weighing for user satisfaction values  $S_i$  obtained for each individual and that will be the final "Overall User Satisfaction" value for the system.

$$S = 1/2[ \min(S_1, S_2, S_3, \dots) + 1/\text{total\#of\_individuals}(S_1 + S_2 + S_3 + \dots) ]$$

## **CHAPTER 3**

### **QUALITATIVE EVALUATIONS FOR SOFTWARE SYSTEMS**

#### **3.1 Protocol Analysis for Evaluating Systems**

Protocol Analysis is proven to obtain subjective inputs from the users of the system. They can put into control condition such as a room without noise, distraction, clear work area, a working system in good condition etc. to obtain correct results about their inputs of the system without influences from obstructing factors. The ‘protocol’ in the protocol analysis is the complete recording of the interaction of a user with a system, while that user ‘thinks out loud’ in order to allow the recording of his or her perceptions, reasoning, and reactions to the system [30]. In the following sections the protocol analysis of the MSN portal has been shown.

##### **3.1.1 Features of the MSN Portal being analyzed**

A web portal has many features and two of them had been chosen to be analyzed in particular. Personalizing the contents of the web portal is being analyzed besides analyzing the user for navigating through the content on the portal. We define personalization as the ability for a web user to customize the content and layout of their own portal web page. It is one of the most successful ways of increasing traffic at portal sites today, and helps to ensure return customers. Typical content options include: local and national news, weather, stocks, sports scores, horoscopes, and favorite links.

Personalization also has navigational value. For many people, browsing the Web is still a slow experience. Personalizing a portal home page is one way to get much of the daily content they're seeking in one location. We also looked at where on the page the personalized information starts. After all, if we go to the trouble of personalizing a page, we want to see information as soon as we display the page—we don't want to have to scroll to see it.

So the crucial areas to focus on include: Providing a single, obvious way to perform a specific task like change the content, layout, color, providing options to cancel actions and return to a personalized home- proper navigation, Avoiding technical or designer jargon. Content on the MSN portal is most elaborate in that it comes from various topics of daily interest. This makes it interesting for anyone surfing the portal a pleasurable experience. The msn portal offers content that caters to the tastes of a wide range of web users. The content of the site is basically the heart of the portal and it appeals the audience to come over and over to the site. The MSN portal has wide ranging topics of interest such as news, chat rooms, games, online organizers and calendars, email and a whole range of information filled sections such as interactive highlights, spotlight, stock quotes.

The user finds information through the web portal and he or she can appreciate the value that it provides. For instance the portal offers to show the latest models of an automobile company, career options with it's career section and entertainment via the entertainment section. There is also the major search engine, which contributes to assist the users in finding content.

### **3.1.2 Protocol Instruments**

Protocol instruments were designed especially to study the msn portal for the said features. The expected inputs from users would be the description of what they found useful, pleasing, valuable, best system utility, support for tasks and also what they did not find useful, displeasing, confusing and missing with the system. With this in mind the protocol questionnaire was designed. Other instruments included a consent form, which would enable the researcher to get consent from the user for the various interactions with the user and the instruction sheet for the exchange of information between the user and researcher. The protocol instruments are found in the appendices. They are labeled as the consent form, instructions for the subject, task lists, and interview questions. Specific to the topic of user interface satisfaction questionnaires have been developed [6].

The sample result report is also presented with his background information, summary of experience, positive aspects of the system (for the subject), difficulties encountered with the system, subjects' and evaluators' comments and suggestions. This result report is particularly important to the evaluation of the system since it is meant to summarize the experiences of the user and the inferences that an evaluator must derive from this. The results must be used to make recommendations to improve the system. In the following sections it is presented how recommendations can be made to make improvements.

### 3.1.3 Analysis Summary and Recommendations

The analysis summary and recommendations are tabulated below. These are put into tabulated form from the result reports prepared after the user carries out the tasks that were assigned and returns the completed post-task questionnaire.

**Table 5** Positive aspects and problems

| Subject | Positive Aspects  | Problems/Difficulties  |
|---------|---|--|
| A       | <ul style="list-style-type: none"> <li>● Volume of information provided</li> <li>● Better information than other sites</li> <li>● Good special sections/features</li> </ul>   | <ul style="list-style-type: none"> <li>● Advertisements were a distracting element</li> <li>● Icons were bad at few places</li> <li>● Repetition of forms</li> <li>● Problem recognizing the utility of a feature – bad interface metaphor</li> </ul>  |
| B       | <ul style="list-style-type: none"> <li>● Links about news items</li> <li>● User interface with good colors and design</li> <li>● Valuable and good information</li> <li>● Being a portal it had all the features that a portal is supposed to have</li> </ul>   | <ul style="list-style-type: none"> <li>● Advertisements were in irrelevant places</li> <li>● Some pages were lacking clarity</li> <li>● On some pages fonts were very bad</li> <li>● Was not able to get what he was expecting at some places</li> </ul>   |
| C       | <ul style="list-style-type: none"> <li>● Formatting is very good.</li> <li>● It provides lots of information.</li> <li>● The pages were very subject oriented.</li> <li>● The pages were very neat and clean and everything was very visible.</li> </ul>  | <ul style="list-style-type: none"> <li>● The links on the site were not relevant.</li> <li>● It really required more search for finding the stuff, as it is not generalized.</li> <li>● Enough stories were required to be complete.</li> </ul>  |
| D       | <ul style="list-style-type: none"> <li>● He liked the option of local as well as international news to be added so that when he logs in he could see the news headlines.</li> <li>● He finds the ads very less.</li> <li>● The access to hundreds of sites and links.</li> <li>● The site is fully and highly interactive.</li> </ul> | <ul style="list-style-type: none"> <li>● Default pages provide details, which are not required.</li> <li>● Proper search is not provided for all the links.</li> <li>● The news section highlighted whether it is gossip, proper catch is not there so that proper arrangement is needed.</li> <li>● The page takes more time to load, as there seems to be more stuff on the page.</li> </ul> |

User interaction with the systems content and personalizing the site was studied and the protocol analysis yields a whole list of recommendations that are made below. Before we present them here was what we thought about the various sessions with the subjects. Subjects certainly did their tasks with commonality. This enables us to make recommendations not based on the user's idiosyncratic notions but about his natural interaction with the system that followed a general set pattern of web usage. There were features in the system that were not liked by the user. However the user expressed satisfaction at places where he found the stuff was very much accessible to him/her.

Most of the common problems that were encountered were in finding things that were placed on the site. Not all features of the site were a problem to access. There were times when the user found that the user interface was pleasing, help was adequate when needed and the menu system was how the user perceived it to be.

Information was of a great value to all the users and they termed the information provided to them as being useful and better than what they had seen on other sites. One subject also appreciated the fact that msn was a good portal having all the features that a portal was required to have. This was very much as expected since msn is one of the largest portals in the world of portals. Specific to pages such as the sports page the content was expected to be categorized into categories such as each separate sport. The user was overloaded with information from various sports rather than the one he liked. On the news content links should have been provided to go to the next article from the user's current location. This would have eased the use of the page in as much as the user would not have to go to the main

page to fetch the piece of news headlines that he is looking for. I should be made available to him from his current location since it is relevant and related information.

**Table 6** Specific recommendations and suggestions

| Suggestion                       | Specific Recommendation to improve  | Recommendation if features does not need improvement or redesign   |
|----------------------------------|---|--|
| User interface improvement       | Fonts, color and background must be improved across the various sections of the site to enable user satisfaction and ease of use. Bright fonts hurt the subject's eye at some places in the site. This must be fixed.                               |  |
| Removing displeasing content     | The advertisements are a source of distraction and displeasure to the user while he interacts with the system. They must be placed more subtly on a page so as not to distract the user.  |  |
| Improving the interface metaphor | Improvement is required in presentation of icons and links. They were misleading at times and did not represent what they were meant to represent.  |  |
| Content in the site              |   | It was greatly satisfying for the user to find the content that he was looking for. For instance movie reviews and stock quotes and information were available and presented well. So this feature must be kept up with. |
| Organization of Content/Chunking | Information/Content should be categorized and presented to him. For instance on a sports page the content should show categories of different sports such as baseball, basketball instead of presenting the content as a large piece of information |  |
| Updating the content             | Check box provided is not of any use. It adds to the confusion.   |  |

### 3.1.4 Inferences about the system

What yields from the exercise of protocol analysis is the capacity of a researcher to present possible improvements to the system and its redesign if required. The features of the system that do not require any specific changes in design can have cosmetic changes take place over them on for the user to find a new look and feel.

The msn portal is a very large system and recommendations made here are on the basis that two subjects were made subject to the protocol. Hence it is necessary that for such a large system the system be tested for usage by many users. It can be said that the usefulness of protocol analysis is high especially when there are not enough sales for the system or when the system is not doing good in the market. It is particularly helpful as a tool for redesign and has unique value to helping make design decisions that were not considered from the user's point of view. When a user speaks out loud about what he/she is doing it is helpful for the researcher to know what reactions a user has to a system and whether or not to improve the systems features.

There is a great demand for user response to the systems deployed in public use. Questionnaires, survey forms and the like will help decide objectively how the system is performing but protocol analysis certainly provides a more complete picture of the user's interaction with the system. The user responses can be interpreted in many different ways to enable the improvement of a system.

### **3.2 Other Qualitative Criteria for Evaluations**

There are many other lines of thinking about qualitative evaluations of systems. The evaluators of the system may be of different kinds. There may be people who take the stand for technological innovations as an advancement of mankind and evaluate systems as being beneficial to mankind. On the other hand segmented-institutionalists consider human factors of systems before rating the system as being beneficial or not beneficial or other such

evaluation. As said by [19] in his paper "Systems rationalists also differ on critical assumptions. For example, many systems rationalists imply that important social decisions can be made with one comprehensive, enduring rationality".

As shown in [19], systems rationalists have different lines of analyses, which makes them different from each other. Just as any person tends to rationalize his thinking about a particular topic or discussion. Systems Rationalists do differ in their opinions of how they analyze certain situations and organizational information systems. Moreover he has separated the systems rationalists to be simply rationalists or structuralists and human relations specialists. Their analysis of technology, social settings, organizing concepts, dynamics of technical diffusion etc. differ. For instance, a system rationalist leader is the one who acknowledges social conflict in a team that is very diverse in its' ideas. He/she will take advantage of this. On the other hand the management scientist type of team leader, as [19] mentions would ignore social conflicts and will be more rigid because of such belief. The following is an argument about the decisions from a decision maker who

A team leader who is a system rationalist (having his/her critical assumptions about a single unequivocal rationalism) or is a structuralist would always focus on achieving his goals considering that there is little to discuss about the acceptance of the information system or technology being used. Such considerations can lead to timely delivery of products or services assuming that there is little social conflict(just like the system rationalists assume). On the other hand segmented-institutionalists, who also do differ in their thinking about the assumptions of

social behavior, while leading a team, would most likely analyze the social patterns of the participating parties or individuals.

Say a team leader or project manager follows the pattern of a segmented institutionalist in thinking that he must analyze the kind of social conflicts that do occur while the project is on its way. This does help in a way if what he assumed turned out to be right. For instance he assumed that all project members must not be seated closely. This is technically untrue but socially true in the sense that there may be conflicting styles of working that affect a projects members' ability to perform in such a setting. On the other hand the system rationalist would argue that it would be more important to focus on achieving goals of the project and that it is assumed that the social conflicts will always persists in a performing group.

Lastly, it can be said that the critical assumptions, that the system rationalists and segmented institutionalists make about the given information system or technology, are proven to be legitimate, after a large population tests them over a long period of time. It is worth pondering of what the greatest downfall of a decision-maker who is a systems rationalist would be, while selecting or evaluating a software. Similarly, it may be questioned of what the greatest downfalls, of the decision made would be, when the decision-maker is a segmented institutionalist.

Another evaluation method is shown as a heuristic evaluation of a world wide web prototype of the bureau of labor statistics(<http://stats.bls.gov/blshome>) site. It has been shown how usability principles like 'chunking', 'progressive levels of detail' etc. can be used as

heuristics for evaluation [21]. Continuing the assessment of the role of ease of use or usability [13], usefulness and attitude in usage of the world wide web a study by [20] shows how their technology acceptance model(TAM) accomplishes these objectives. Another survey of user attitudes towards computers is shown in the study by [24].

## **CHAPTER 4**

### **DECISION MAKING BASED ON MULTIPLE CRITERIA FOR SYSTEMS**

There are various ways investments in information technology are made by evaluating systems [7]. [9] lays a foundation for the use of GDSS. In [11] it has been said that computer systems are used for an individual's decision making for business, and most strategic decisions are ultimately made by an individual, rather than a group. A group has been shown using computers in high-level decision-making [11]. The problem of making decisions considering multiple attributes of the system is a difficult. The difficulty of making choices or selecting from various products is particularly seen in investing huge amounts of capital in them. It is therefore important to identify the right attributes of the system for them to be evaluated. The problem here is that once a set of attributes common to each system is found a method is chosen to evaluate them. Quite often it is difficult to rate an attribute quantitatively against that of another system. It may be quite easy to subjectively describe how well the attribute of one system does against another. To remove this fuzziness a method is devised to quantify the decision makers' reactions.

#### **4.1 The Database Selection Problem**

A specific problem chosen here is that of choosing academic databases. Many instances occur when expensive databases must be chosen. This is a capital investment project. Similar investments in technology and especially software must be evaluated before any decisions are made. Decisions made should be based on such evaluations. The problem of database

selections in particular has been encountered many times and is assessed using various methods. Some methods focus on the testing the query itself and the number of documents retrieved. As mentioned earlier research has been done for effectiveness of solutions for such problems as selecting the optimum database for a given query based on the decision about which database, from a number of given databases, should be chosen for that query. This is very specific to the query and hence a collection of queries can be formulated and cumulative costs can be computed [25]. The reason is that with relevant documents irrelevant documents are retrieved. The key criteria of analysis may be based on precision and recall [5].

With this in mind the issue of selecting databases does not become easier. The value of research done should be for real work places. The application of this research is often unseen because decisions made are ad hoc and except in large corporations the use of tools for decision making is limited because of the overheads involved. Often this is due to economically limiting factors. Some employees of large corporations were informally interviewed regarding the use of decision aids. They all denied and said that the use of decision aids was not prevalent because importance was given to solution formulation and not selecting the solution as is most often the case with decision-making. They also recorded the fact that investments in capital or the formulation of a solution for building large software applications was primarily done by managers and chief technical officers. They reported the non-use of a structured approach to making such decisions. This was done purely based on the experience of the team leader or manager.

Proposed here is an approach to making selections for capital investment projects. GDSSs have been defined as integrated computer-based systems that facilitate solution of semi- or unstructured problems by a group that has joint responsibility for making decisions [1]. Keeping this in mind a software program was built to implement the solution to the problem of making selections. It can be called a Decision Support System simply because it generates a decision in the form of a table where product ratings are displayed from highest to lowest. The solution consists of first preparing a set of attributes or features that a vendor provides for his product. Then each vendor is rated for a feature. A weight is given to the feature. The weight is also decided by each of the decision-makers. The weight is assigned to the attribute or the feature of the product after all the rating sheets are filled in. The rating-sheet consists of a matrix like table in which vendors are placed as columns and the attributes or features are placed as rows. Each cell carries in it a rating value for the corresponding feature and vendor. The rating sheet for each decision maker is then combined to form a single tabulated rating table by performing various computations on it. The computation basically consists of pessimistically averaging the rating provided by each of the decision makers. These are explained in the following section. The weights assigned to each feature are then pessimistically averaged similar to the ratings.

The rating matrix and weights matrix are then combined by multiplying the weight matrix with the rating matrix to get a complete effect of the rating. With this a final matrix is produced which is a simple one-dimensional matrix with the highest numeric value placed first following with the remaining numerals in descending order. The meaning of this matrix is that the highest rated vendor is placed first and then the remaining follow. The highest rated

vendor is the collective choice of all the decision-makers. The detail of how the computation is performed on the ratings and weights is shown in the next section.

#### **4.2 Selecting the Right Database Product: A fuzzy logic approach**

In the previous section it has been described of how a fuzzy qualitative decision about a database can be quantified and brought to the stage where a decision is generated as numeric output produced from the computation. This means that the database/vendor that got the highest numeric value will be chosen. The following is an account of what the Decision Support System will do.

First the vendors and attributes are selected. The attributes are the various system features. The academic databases come with more than one module for support of the various departments of the library. A module may support the inter-library loan department with its, say, ILL feature whereas another may support the reference department with its SEARCHING feature etc. The vendors are commercial database vendors. The following is an overall algorithm for the computation of the final matrix.

1. Select the set of vendors and set of attributes
2. Rate each attribute with respect to each vendor
3. Compute the modified pessimistic aggregated rating(MPAR) matrix for vendor v/s attribute
4. Assign a weight to each attribute

5. Compute the weighting vector
6. Multiply the MPAR matrix by the weighting vector

In this model there are k decision makers. Each decision maker will be evaluating each of i attributes against each of the j integrated library systems. Each decision maker will be presented with a rating worksheet arranged such that the rating for the  $i^{\text{th}}$  attributes against each of the j integrated library systems.

Each decision maker will be presented with a rating worksheet arranged such that the rating for the  $i^{\text{th}}$  attribute with respect to the  $j^{\text{th}}$  alternative will be done in the interval  $[0, 1]$  or  $[0, 10]$  with the 0 meaning that the attribute is least important and 1 or 10 meaning that the attribute is most important.

**Table 7** Matrix for vendors versus attributes

| Attributes   |          | Vendors or Alternatives |          |          |
|--|----------|-------------------------|----------|----------|
|  | Vendor 1 | Vendor 2                | Vendor 3 | Vendor 4 |
| Advanced searching feature                         | rating   | rating                  | rating   | rating   |
| Accept variable barcodes                           | rating   | rating                  | rating   | rating   |
| Customization option                               | rating   | rating                  | rating   | rating   |
| Patron generated ILL                               | rating   | rating                  | rating   | rating   |
| Patron notification upon arrival of item via email | rating   | rating                  | rating   | rating   |

The modified pessimistic aggregation is calculated as follows. The ratings are picked from the cells by the DSS program and the computation that has been shown is performed.

$$r_{\text{pess\_mean}} = \frac{1}{2}[\min(r_{ij}^1, r_{ij}^2, r_{ij}^3, \dots) + (1/k \sum_{k=1}^k (r_{ij}^k))]$$

$r_{12}^1$  = rating value of decision maker 1 for attribute 1 with respect to vendor/alternative 2.

In the above formula,

i represents an attribute or a variable,

j represents a vendor or a database alternative,

k represents the decision maker

The rating of the  $k^{\text{th}}$  decision maker is for the  $i^{\text{th}}$  attribute with respect to the  $j^{\text{th}}$  alternative. Now the pessimistic mean must be calculated. The DSS does this for the user. This is done in the following manner. The DSS reads the rating values given by each of the  $k$  decision makers for attribute 1 and vendor 1. The minimum from the values of ratings  $r_{ij}^k$  is selected as

$$r_{\min} = \min(r_{ij}^1, r_{ij}^2, r_{ij}^3, \dots).$$

The mean is then computed for each  $r_{ij}^k$  by summing the values and dividing by the number of decision makers.

$$r_{\text{ave}} = 1/k [\sum_{k=1}^k (r_{ij}^k)]$$

The mean of  $r_{\min}$  and  $r_{\text{ave}}$  gives the  $r_{\text{pess\_mean}}$

$$r_{\text{pess\_mean}} = \frac{1}{2} [r_{\min} + r_{\text{ave}}]$$

Now the DSS will ask the decision makers for weight to be assigned to each attribute. This is interpreted as the importance of the attribute to the institution or the organization making the selection. Weights to each attribute on the list are assigned as a number from interval [0, 1] or [0, 10] with the 0 meaning that the attribute is least important and 1 or 10 meaning that the attribute is most important. The modified pessimistic weight is calculated as

$$W_{\text{pess\_mean}} = \frac{1}{2}[\min(W_i^1, W_i^2, W_i^3, \dots) + (1/k \sum_{k=1}^k (W_{ij}^k))]$$

Where W stands for weight. And the meanings of i and k remain the same. Finally when the weighing matrix, which is a (1 \* n) matrix is multiplied by the rating matrix, which is a (n \* m) matrix it yields a (1 \* m) matrix which contains the final decision matrix. The decision matrix contains numeric values from the highest to the lowest with the vendor name showed against each value. Hence it can be found which vendor rated the best according to the decision-makers. The final table of results or the decision-matrix appears as shown below.

**Table 8** A tabulation of the ratings for alternate solutions/vendors/databases  
(for this study)

| Vendor 1 | Vendor 2 | Vendor 3 | Vendor 4 | Vendor 5 |
|----------|----------|----------|----------|----------|
| 9.75     | 8.45     | 7.25     | 6.32     | 5.77     |

Values in the above table are fictitious. The matrix shows that Vendor 1 is the collective choice of the decision makers. In the following section an experiment has been devised to

measure the satisfaction with the outcomes of the decision from the use of such a DSS. The experiment is just a design and hence the data presented therein is hypothetical to prove the objectives of the experiment. In certain cases decision makers may feel that though they rated certain vendors very highly for their products(in this case the databases) those vendors were not selected since many others may have rated other vendors highly. The use of a face-to-face(FTF) discussion for discussing the issues that remained unresolved from the use of the DSS is warranted.

The DSS designed for the purpose of this solution does not allow group communication. It only automates the process of decision and aids in reducing of the fuzzy behavior of the qualitative evaluations. The design of the experiment suggests whether the use of FTF after using the DSS is beneficial to the group or not. The DSS was built to make computations and get inputs from decision makers. However the input module, which allows input from the user and the computational module that read in users' inputs are run in separate sessions one after the other i.e. the input module must be run and then the computational module. The DSS runs in line mode and a GUI is being worked on. Besides, an evaluation plan for actually conducting the experiment is also being worked on. The evaluation plan will make cost suggestions for the use of DSS and FTF-discussions to evaluate the databases.

## **CHAPTER 5**

### **ANALYZING THE USE OF DECISION SUPPORT SYSTEMS**

The case study shown here is a collection of two case studies, in research papers [17], [18], that are focused very closely to the topic of current discussion. Hence their findings and methods of analysis are very important to the study of the use of Decision Support Systems. The inferences derived from there are very helpful in analyzing systems in organizations. Though systems are evaluated quantitatively they do not involve the use of statistical analysis and factors of value around the system. By this it means that evaluations of systems focus on the apparent factors such as functionality of the system, the capabilities of the system, its usability etc. However there is no kind of research value added to it in that there is most likely no thought given to interaction of system factors, psychological factors, human factors etc. The formulation of a hypothesis (has been shown in the following sections) for these factors helps analyze the selection or evaluation better. Statistical analysis then helps to analyze and evaluate the system produce numeric values for certain analytic factors such as F, t, p etc., which are then interpreted to mean something for the system under consideration. This means that the end value of this analysis is for instance whether a system must be chosen or not, a system did better than the others etc.

Two case studies are chosen were experiments on the use of GDSS in auditing. The first study that was published in 1994 [18], primarily studies the effects of the communication medium on learning and satisfaction of the subjects that either worked in a (face-to-face) FTF,

GDSS (Group Decision Support Systems)-mediated or an independent environment. The following study which showed continued research in this field was published in 1996 [17] and it studied the choice-shift phenomenon occurring with the use of GDSS, efficiency of the performing group and the perceived satisfaction of the participants in each group - FTF, GDSS-mediated and individuals working independently.

### **5.1. Learning in Co-operative environments and the Use of Decision Support Systems**

This first study [18] mainly describes the use of GDSS tools in making decisions in auditing such as audit planning, risk assessment and setting the materiality level for a client. This study has been referred to as study 1 [18]. The paper examines the various effects of GDSS on groups. For instance learning is a positive effect of GDSS. This has been studied by comparing the extent of learning for participants in individual decision making environment, FTF environment, and GDSS environment. The nature of the study is therefore conceptual as well as empirical. Results of the learning experiences have been presented.

On the second study [17] continued research has been shown on the topic of group decision making in auditing tasks. This study has been referred to as study 2 [17]. The research primarily focuses on the topics of the choice-shift phenomenon (explained later) efficiency of groups (GDSS-mediated and FTF) and the level of perceived satisfaction for these groups. Like the first experiment this one also has the group of individuals working independently. The experiment has been done in two

stages. The first one is done to test the hypothesis that the extent of shift in acceptable audit risk (AAR) level for the two communication modes (GDSS-mediated and FTF).

The second stage of the experiment investigates whether the difference in the extent of choice shift observed between the GDSS-mediated and FTF groups was due to the presence of the automated decision aids or was due to the anonymity of individual members inputs. In this part of the experiment anonymity was manipulated (anonymous v/s non -anonymous) while holding communication condition constant (i.e. GDSS-mediated).

### **5.1.1 Hypotheses for Accomplishing the Objective**

There were two set of hypothesis in study 1 [18] that were used to analyze the participants in the groups using either GDSS or FTF discussions for making decisions for audit planning, risk assessment and setting the materiality level for the client. The hypothesis mainly consisted of two parts. The first set of hypothesis was regarding the effect of the communication medium of learning. This meant that whether the medium used to make decisions helped the users learn and make better decisions or not.

H1A: Subjects in GDSS-mediated groups will exhibit greater learning than subjects in the FTF groups.

H1B: Subjects in GDSS-mediated groups will exhibit greater learning than subjects working individually.

The second set of hypothesis was used to analyze the satisfaction in group processes. The subjects were made to answer questionnaires regarding their satisfaction level, perceived improvement etc.

H2A: Subjects in GDSS groups and subjects in FTF will have equivalent satisfaction levels with the group experience.

H2B: Subjects in GDSS groups and subjects in FTF will have equivalent satisfaction levels with the outcome of the group deliberations.

H2C: Subjects in GDSS groups and subjects in FTF will have equivalent self-reported group efficiency ratings.

H2BD: Subjects in GDSS groups and subjects in FTF will have equivalent levels of perceived improvement.

In [17] To study the phenomenon of choice shift in GDSS-mediated environments and its difference from the FTF environment for which decisions made are considered to be the usual norm or standard. It has been intriguing to the researchers about whether the significant choice-shifts or group-shifts would be observed for a GDSS-mediated group. The question now arises whether the group shifted into a risky or a cautious decision due to the mediation of the decision aid. The answer is task dependent and is not of concern for the research. What is however of interest here is whether the shift was caused due to the anonymity of the group or due to the intervention of technology.

To test these uncertain ideas certain hypothesis were proposed and subjects were assigned to various groups. Then tasks would be assigned to each group. Later measures of

their experiences would be done via standard measuring instruments such as questionnaires etc. The hypothesis and the reasons for them are as follows.

H1: GDSS-mediated groups will exhibit the same degree of choice shift as face-to-face groups.

H2: The time required to reach a consensus will not be significantly different between GDSS-mediated and FTF groups.

H3: Satisfaction with the group process will not be significantly different between GDSS-mediated and face-to-face groups.

The first hypothesis was primarily proposed to test the intervention of GDSS technology in decision-making. The traditional FTF meeting for group decision-making is understood to be the standard. However choice-shift does occur in that the group will tend to deviate from the task from distracting comments by individuals, intervening of a member with an irrelevant point of discussion etc. Also the dominance of the individual making the comments must be considered since he/she may not be easy to prevent from talking or distracting the group.

The GDSS-mediated group is put to question about whether there does or does not occur a choice shift in decisions made. There may not be distracting comments due to each person on the GDSS would likely to prevent himself from presenting such ideas that have unknown reactions from the participants. This might enable the group to comply with the rules and focus on the task at hand. The efficiency might be a crucial factor. It might be higher than the FTF group. To test this a second hypothesis is made.

The second hypothesis states whether or not the time required to reach a consensus will be different in the two groups. This could mean that a group placed under mediation of GDSS for making decisions may perform better and faster than the FTF group with the anonymity that was provided to it. However the converse may be true in that the FTF group may be more satisfied and perform more efficiently given that it has the liberty to freely interact with the other group members without any mediation or obstruction (if it so feels to the members) of technology. The third hypothesis tests the satisfaction of the groups using GDSS and those that use FTF meetings to make their decisions. This is a crucial factor to decide the use of GDSS technology versus traditional FTF meetings.

### **5.1.2 Methods, Tasks and Conducting the Experiment**

In study 1 [18], the subjects were asked to perform the task of assessing audit risk in the environment of GDSS-mediation and FTF meetings. The subjects were given pre-treatment test and post-treatment test. The pre-treatment test was administered to assess the subject's initial knowledge of internal controls relevant to the purchase segment of the acquisitions/cash disbursement cycle. The subjects were then subjected to the treatment task, which, consisted of working either individually, working FTF or working in a co-operative environment with the GDSS. The GDSS-mediated group used the VisionQuest GDSS software.

After the treatment task the subject's internal control questionnaires and client descriptions from the pre-test phase were returned to them. The subjects were instructed to make any additions and corrections to the questionnaires returned to them.

Learning effects were measured by observing the difference in the number of internal control questions between pre-test and post-test. The measure of satisfaction was from the questionnaire, whose responses were to be entered on a Likert scale. For instance one question had the two extremes as “very dissatisfied” and “very satisfied”.

The second study [17] had two stages. Stage one the subjects were asked to make an audit judgment task individually and then repeat the task in a group setting. The task involved determining the level of acceptable audit risk for a hypothetical client. Audit risk is considered as the probability that an auditor will fail to notice an existing misstatement in the client’s accounting records and as a result issue a clean audit report instead of issuing an alert about the misstatement.

The appropriate level of acceptable audit risk must be determined for audit processes. If acceptable audit risk is set too high then the auditor may be performing a substandard audit. This might lead to legal liability of the auditor if the client defects. If the acceptable audit risk is set too low then the auditor may have to perform audit that is of very high standard to catch all or nearly all misstatements and mistakes in the clients accounting records. Control was exercised to that there was no interaction between subjects when they completed the task individually. Following the completion of the task individually they were placed in a group. The group was then subjected to make decisions about the acceptable audit risk level either in a GDSS-mediated or in a FTF meeting environment.

### 5.1.3 Results and Findings

On the first study [18] F tests have been done and the results suggest that the subjects working in GDSS-mediated co-operative groups learned more than subjects in the FTF groups and subjects working individually. There was no difference between the levels of learning improvement between the FTF and individual group. These results met the expected hypothesis effects. The hypotheses were tested by finding the mean change in subject's pre-treatment and post-treatment scores (learning effects).

The learning effects scores in the GDSS group was compared to the learning effect scores in the FTF group. The differences in pretreatment and post-treatment scores were marginally significant. It was found as said before that GDSS group learnt more than the FTF group and there was not much difference between levels of improvement for FTF and individual. Another part of this experiment dealt with measuring the level of satisfaction in the three groups (individual, GDSS-mediated and FTF). The measured level of satisfaction indicated that the FTF group was more satisfied than the GDSS-mediated group in the results or outcome of the group deliberation. A hypothesis proposed by the researchers that both the GDSS-mediated and FTF groups will have equal satisfaction was rejected. This was supported by the fact that the GDSS-group gave lower efficiency rating than the subject in the FTF groups.

This part of the study also tried to prove a hypothesis about the improvement in ability to perform similar tasks in the future. The results indicated that individuals working

independently were less confident that their assignment had improved their ability to identify weakness in the internal control structures (internal control structures are said to be ones that control the transactions for acquisitions/cash disbursement cycle) than subjects in the FTF group and subjects in GDSS-mediated groups. Co-operative environments increase subjects perceptions that treatment task (going through a group deliberation) improved their decision-making ability. The FTF groups were more confident of their improved ability than GDSS-mediated groups. The methods used for finding the measures of satisfaction and measure of perceived improvement, F-test were used. In a certain case where the four satisfaction questions were to be measure for reliability, the Cronbach's alpha was used. A Cronbach's alpha of 0.92 was obtained.

The results from the two stages from the second study [17] are as follows. Stage one results were analyzed by performing paired-samples t-tests to test the first null hypothesis that mean individual AAR was not significantly different from the group AAR in each communication mode. The second hypothesis was tested by taking the two communication modes into consideration. t-tests were used and it was found that subjects in FTF took longer than subjects in the GDSS-mediated group to reach a consensus.

The third hypothesis was tested by comparing subject's satisfaction ratings of their satisfaction with the group process based on their responses to certain questions in the debriefing questionnaire. A reliability analysis of the questionnaire revealed a Cronbach's alpha of 0.79 indicating that it can be considered a reliable measure for subject's reactions to the group process.

The results from the second stage are as follows. Here anonymity was manipulated as being anonymous v/s non-anonymous while holding GDSS-mediated communication mode constant. This stage of the research clears up any gray areas regarding the cause in difference in the extent of choice shift between GDSS-mediated and FTF due to the mode of GDSS i.e. anonymous or non-anonymous. The means of individual and group ratings were close. A paired-samples t-test was performed to test the significance of the shift, the results shown that the difference between the individual and group means for the non-anonymous GDSS-mediated group was not significant. No significant choice-shift was observed for non-anonymous GDSS-mediated groups.

Considering the results of stage one the extent in choice-shift can be attributed to the mode of communication and not anonymity in the GDSS-mediated group. From results of stage 1 and stage 2 specifically GDSS technology can serve to mitigate the choice-shift phenomenon commonly observed in the outcome of group decision processes. Also a significant "cautious choice-shift" was observed in the FTF group whereas there was no choice shift observed in either anonymous or non-anonymous groups.

## **5.2 Critical Comments on Methods Used for Data Analysis in the Case Study**

The authors researched the usefulness of GDSS in auditing tasks over FTF and individual efforts. The designed hypothesis for testing and their primary method of analysis appears to be factorial design. Since only the results are presented on both papers it can be only presumed of what method would have been used.

In the most common scenario the method of reporting scores were the means and standard deviations of the individuals in respective groups. The t-tests have been performed on study 2 [17] and F-tests were performed in study 1 [18]. The two research scenarios were done with an intention to further their knowledge in the field of 'use of GDSS in auditing'. F-tests reported the results of the hypothesis for instance "the subjects in GDSS-mediated group will exhibit greater learning than subjects in FTF groups (study 1 [18]).

Paired-samples t-tests were performed to test null-hypothesis in the research scenario assessing acceptable audit risk (AAR) in GDSS-mediated, FTF and individual environments. This was meant primarily to compare group means. The results indicated that the hypothesis did hold. A smaller value of  $t$  obtained indicating that mean individual AAR was not significantly different from group AAR in each of the two communication modes proved that hypothesis. A significant value of  $t$  obtained showed that there was a significant difference in mean values between individual and FTF groups.

### **5.2.1 Problems, Limitations and Assumptions**

There were no problems and limitations found in the study. In the experiment (study 1 [18]) the one-way ANOVA was appropriate to use. However since the experiment consisted of pre-treatment tasks and post-treatment there could have been possible invalidity of results. Internal validity is particularly in question because there could have been learning going on between the pre-treatment and post-treatment tasks.

### **5.2.2 Alternative Ways of Analyzing Data**

Alternate ways of analyzing the data would have been to calculate eta and prove the size-effects of each of the independent variables. This was not shown on the study in either paper. The primary reason is that eta can serve as an index of any type of relationship.

### **5.3 The Proposal of a Method for Testing the Use of Decision Support Systems**

The experiment is based on the subject of 'selecting academic databases'. This study is real and this part of the study i.e. the experiment is hypothetical. The task at hand here is the selection of academic databases that cost millions of dollars and are crucial to the faculty and student population. The selection of the right databases is therefore of prime concern for meeting the financial budgets. The tasks of selecting a database involve the various decision makers who make decisions for selecting the databases from various vendors.

The task of selection can be done by the head of the department alone or involve the staff from the different departments of the institution. A certain DSS will be used to assist the decision makers to make the crucial selection. The DSS enables its users to rate and weigh various database attributes for each vendor. Each user can fill-in a rating sheet and then the rating sheets are brought together by the DSS and a final result is thrown out as a table containing the vendor with it's corresponding rating, the vendor with the highest rating standing at the top.

The task of selection can now be done either by

- (a) Using the DSS (DSS-assisted)
- (b) Not using the DSS and using FTF communication for the deliberation of selecting the database
- (c) The DSS followed by FTF discussion for any unresolved issues
- (d) Individually

The subjects the on the experiment are hypothesized as the members of the department wanting to make a database selection. It is not described how the subjects would be assigned to the group.

### **5.3.1 The Foundation for the Testing Method**

The independent variables therefore entail the 'mode of decision making' - i.e.

- 1. DSS assisted
- 2. FTF
- 3. DSS-assisted + FTF
- 4. Individual

The independent variable 'mode of decision making' therefore toggles or is manipulated as the above-mentioned modes. The dependent variable is the 'satisfaction' of the users with the process of decision-making. The overall satisfaction reflects the agreement of all members of various departments to the consensus of having chosen the right databases during the exercise.

Satisfaction entails overall satisfaction with the group process as said before and satisfaction due to improvement in the financial spending (which may include savings due to the choice of the new set of databases, benefits due to the new configuration of databases and improvement in services).

### **5.3.2 Design and Procedures**

Here is a description of the design and procedures of the experiment. The instruments such as the questionnaire was adapted from study 1 [18]. The data analysis procedures were adapted from [27]. The financial budgets are assumed to have been calculated before and after the selection of the new set of databases to analyze if the institution profited or lost by reconfiguring their set of databases. A profit may not necessarily be only in terms of dollar amount. It is left to the institution or environment's decision maker community who will decide whether they perceived profit or satisfaction as has been said before about satisfaction/improvement. It is also assumed that the new set of databases may not have at least one new database or have at least one old database eliminated from the old set of databases.

The questionnaire was designed much on the lines of the satisfaction questionnaire of the study 2 [17] experiment. It was brain stormed of the questions that could be asked to the potential decision maker about working with the group, outcome of the group decision and their experience. Three questions were aimed at satisfaction due to improvement in the financial spending scene of the institution and three were for measuring the overall

improvement for working with the group and the DSS. The responses to each question were measured using the 7-point Likert scale with each scale having the two extremes of the reaction to the question. The questions and scales are as follows:

1. The institution profited financially by saving on database costs by reselecting their set of databases.

| 1<br>Will lose<br>heavily | 2<br>Will lose | 3<br>Will<br>somewhat<br>lose | 4<br>Neither<br>profit nor<br>loss | 5<br>Will profit<br>somewhat | 6<br>Will<br>profit | 7<br>Profited<br>highly |
|---------------------------|----------------|-------------------------------|------------------------------------|------------------------------|---------------------|-------------------------|
|---------------------------|----------------|-------------------------------|------------------------------------|------------------------------|---------------------|-------------------------|

2. The institution profited financially by replacing the old ill-performing databases by newer and better performing databases.

| 1<br>Will lose<br>heavily | 2<br>Will lose | 3<br>Will<br>somewhat<br>lose | 4<br>Neither<br>profit nor<br>loss | 5<br>Will profit<br>somewhat | 6<br>Will<br>profit | 7<br>Profited<br>highly |
|---------------------------|----------------|-------------------------------|------------------------------------|------------------------------|---------------------|-------------------------|
|---------------------------|----------------|-------------------------------|------------------------------------|------------------------------|---------------------|-------------------------|

3. How would you describe your experience when working with your group?

| 1<br>Very<br>dissatisfied | 2<br>Dissatisfied | 3<br>Somewhat<br>dissatisfied | 4<br>Neither | 5<br>Somewhat<br>satisfied | 6<br>Satisfied | 7<br>Very<br>satisfied |
|---------------------------|-------------------|-------------------------------|--------------|----------------------------|----------------|------------------------|
|---------------------------|-------------------|-------------------------------|--------------|----------------------------|----------------|------------------------|

4. How satisfied were you with your groups' list of new recommendations for selecting the set of databases?

|                           |                   |                               |              |                            |                |                        |
|---------------------------|-------------------|-------------------------------|--------------|----------------------------|----------------|------------------------|
| 1<br>Very<br>dissatisfied | 2<br>Dissatisfied | 3<br>Somewhat<br>dissatisfied | 4<br>Neither | 5<br>Somewhat<br>satisfied | 6<br>Satisfied | 7<br>Very<br>satisfied |
|---------------------------|-------------------|-------------------------------|--------------|----------------------------|----------------|------------------------|

5. How efficient was your group at discussing the present selection criteria and developing recommendation for the new database.

|                          |                  |                              |              |                            |                |                        |
|--------------------------|------------------|------------------------------|--------------|----------------------------|----------------|------------------------|
| 1<br>Very<br>inefficient | 2<br>Inefficient | 3<br>Somewhat<br>inefficient | 4<br>Neither | 5<br>Somewhat<br>efficient | 6<br>Efficient | 7<br>Very<br>efficient |
|--------------------------|------------------|------------------------------|--------------|----------------------------|----------------|------------------------|

6. To what extent do you feel this group improved the selection process?

|   |                                 |                        |              |                           |               |                               |
|---|---------------------------------|------------------------|--------------|---------------------------|---------------|-------------------------------|
| 1<br>Worsened<br>the<br>process<br>highly | 2<br>Worsened<br>the<br>process | 3<br>No<br>improvement | 4<br>Neither | 5<br>Somewhat<br>improved | 6<br>Improved | 7<br>Very high<br>improvement |
|---|---------------------------------|------------------------|--------------|---------------------------|---------------|-------------------------------|

### 5.3.3 Hypotheses for the Main Effects and Interaction Effects

The hypothesis related to the main effects of the modes of communication to the selection process and perceived satisfaction of the participant decision makers are as follows:

H1: The DSS will improve the financial scene (saving, benefits, satisfaction) better than FTF.

H2: FTF improved the financial scene better than using the DSS.

H3: Individual doing the task would not do better than DSS

#### **5.3.4 Method for Data Analysis**

Here is a table of data that has been hypothesized to match the hypothesis. The scores are mean scores from the satisfaction questionnaire. The satisfaction scores are the key scores that are being measured. Also satisfaction includes a user's overall satisfaction and the user's satisfaction due to improvement in the selection process.

**Table 9** Hypothetical test results

|     |                | DSS |      | Row Means | Row Effect |
|-----|----------------|-----|------|-----------|------------|
|     |                | Yes | No   |           |            |
| FTF | Yes            | 7   | 3    | 5         | 1          |
|     | No             | 4   | 2    | 3         | -1         |
|     | Column Means   | 5.5 | 2.5  | 4         |            |
|     | Column Effects | 1.5 | -1.5 |           |            |

The interaction effects calculated are tabulated as follows

**Table 10** Interaction Effects

| Communication Mode | Interaction Effect | = Group-Mean | - Grand Mean | - Row Effect | - Column Effect |
|--------------------|--------------------|--------------|--------------|--------------|-----------------|
| DSS + FTF          | 0.5                | 7            | 4            | 1            | 1.5             |
| FTF                | -0.5               | 3            | 4            | 1            | -1.5            |
| DSS                | -0.5               | 4            | 4            | -1           | 1.5             |
| Individual         | 0.5                | 2            | 4            | -1           | -1.5            |
| Totals             | 0                  | 16           | 16           | 0            | 0               |

The row effects show that the groups subjected to the use of FTF communication and meeting for making decisions perform better than those not meeting FTF (1.0 to -1.0). The column effects show that groups using DSS perform better than the ones that do not. The interaction effect was that the group that uses both the DSS and FTF-meeting and the group that uses neither do better than the ones that use either of the two (DSS or FTF singly).

$$\text{Total SS} = \sum (X - \bar{M})^2$$

$$\text{Between Condition SS} = \sum [n_k(M_k - \bar{M})^2]$$

$$\text{Within Condition SS} = \sum (x - M_k)^2$$

$$\begin{aligned} \text{Therefore Total SS} &= (8-4)^2 + (7-4)^2 + (6-4)^2 + (4-4)^2 + (3-4)^2 + (2-4)^2 + (5-4)^2 \\ &\quad + (4-4)^2 + (3-4)^2 + (3-4)^2 + (2-4)^2 + (1-4)^2 \\ &= 50 \end{aligned}$$

$$\text{Between condition SS} = 3(7-4)^2 + 3(3-4)^2 + 3(4-4)^2 + 3(2-4)^2 = 42$$

$$\begin{aligned}\text{Within Condition} &= (8-7)^2 + (7-7)^2 + (6-7)^2 + (4-5)^2 + (3-3)^2 + (2-3)^2 + (5-4)^2 + (4-4)^2 + (3-4)^2 + (3-2)^2 + (2-2)^2 + (1-2)^2 \\ &= 8\end{aligned}$$

Total SS = Between SS + Within SS  $\rightarrow 50 = 48 + 2$  is now true

Now the degree of freedom within conditions and between conditions is as follows:

$$df(\text{between conditions}) = k - 1 = 4 - 1 = 3$$

$$df(\text{within conditions}) = \sum(n_k - 1) = (3-1) + (3-1) + (3-1) + (3-1) = 8$$

$$df \text{ total} = df \text{ between} + df \text{ within} = 3 + 8 = 11$$

Calculating F:

$$F = S_{\text{mean}}^2 / S^2$$

**Table 11** Table of effects

| Condition    | Subject number | Score | Grand mean | Row Effect | Column Effect | Interaction Effect | Error |
|--------------|----------------|-------|------------|------------|---------------|--------------------|-------|
| DSS + FTF    | 1              | 8     | 4          | 1          | 1.5           | 0.5                | 1     |
| DSS + FTF    | 2              | 7     | 4          | 1          | 1.5           | 0.5                | 0     |
| DSS + FTF    | 3              | 6     | 4          | 1          | 1.5           | 0.5                | -1    |
| FTF          | 4              | 4     | 4          | 1          | -1.5          | -0.5               | 1     |
| FTF          | 5              | 3     | 4          | 1          | -1.5          | -0.5               | 0     |
| FTF          | 6              | 2     | 4          | 1          | -1.5          | -0.5               | -1    |
| DSS          | 7              | 5     | 4          | -1         | 1.5           | -0.5               | 1     |
| DSS          | 8              | 4     | 4          | -1         | 1.5           | -0.5               | 0     |
| DSS          | 9              | 3     | 4          | -1         | 1.5           | -0.5               | -1    |
| Individual   | 10             | 3     | 4          | -1         | -1.5          | 0.5                | 1     |
| Individual   | 11             | 2     | 4          | -1         | -1.5          | 0.5                | 0     |
| Individual   | 12             | 1     | 4          | -1         | -1.5          | 0.5                | -1    |
| $\Sigma X$   |                | 48    | 48         |            |               |                    |       |
| $\Sigma X^2$ |                | 242   | 192        | 12         | 27            | 3                  | 8     |

The two-way ANOVA table is shown below. This reports the F calculated with the formula shown above and eta as follows:

$$\text{Eta} = \sqrt{[\text{SS between} / (\text{SS between} + \text{SS within})]}$$

The MS field is calculated by dividing the SS by degree of freedom df. The p or probability is looked up on the F table for the given between conditions and within conditions dfs.

**Table 12** Table of variance for two-way ANOVA

| Source             | SS | Df | MS   | F  | Eta  | p              |
|--------------------|----|----|------|----|------|----------------|
| Between conditions | 42 | 3  | 14   | 14 | 0.92 | 0.0053(approx) |
| FTF(Row)           | 12 | 1  | 12   | 12 | 0.77 | 0.1(approx)    |
| DSS(Column)        | 27 | 1  | 27   | 27 | 0.77 | <0.001         |
| Interaction        | 3  | 1  | 3    | 3  | 0.52 | 0.15(approx)   |
| Within Conditions  | 8  | 8  | 1    |    |      |                |
| Total              | 50 | 11 | 4.55 |    |      |                |

### 5.3.5 Inferences and Comparison with Case Studies

The larger the MS for the between condition source of variance relative to the within-condition source of variance relative to the within-condition source of variance, the less likely the null hypothesis that there occurs no difference between the condition means becomes true[27]. An F(3, 8) of 14 between conditions, F(1, 8) of 12 for FTF and F(1, 8) of 27 for DSS and F(1, 8) of 3 for Interaction were obtained. The size of the effect estimate eta was used and was found to be 0.92(largest) and 0.52(lowest). Eta<sup>2</sup> is interpreted as a proportion of variance.

Therefore  $\eta^2$  equals 0.85(largest) and 0.27(lowest). Since there aren't only two conditions being compared eta may not represent a linear relationship. P expresses the probability that an eta of the size obtained or larger could have occurred if the relationship between the independent variable of condition membership and the dependent variable of score on the response variable were actually zero in the population [27]. Eta is therefore a very non-specific index of effect size when it is based on a source of variance with  $df > 1$  and is much less informative than which tells us about linear relationship. The eta of 0.92 is based on a df of 3 for between-conditions effect and is large. The etas for FTF(indicating row), DSS(indicating column) and interaction are based on a single df and it is therefore equal to correlation 'r'. It can be said that the size of the effect of FTF is  $r=0.77$  and that for interaction is 0.52.

The group working in DSS was more satisfied about the improvement of the financial budgeting for databases showing( $F(1, 8)=27, p<0.001$ ) as opposed to the FTF group ( $F(1, 8)=12, p=0.01$ ). Since a two-way analysis of variance was done the results especially the size of effects estimates regards each of effect of analysis(row, column and interaction effects) as though it were the only one investigated in that study.

The results in the study conducted on the research paper (study 1 [18]) indicate greater satisfaction for FTF rather than GDSS-mediation for their own group experience. The findings for the hypothetical scenario here(selecting the database) indicate greater overall satisfaction for DSS mediated decision-making. study 2 [17] reports greater learning from FTF

was greater than GDSS mediated. My findings are opposite for the fact that the use of DSS followed by FTF meetings for resolving unresolved issues or discussing any fuzziness about their decisions, increased user ability to make decisions.

## **CHAPTER 6**

### **RESOURCE ESTIMATES**

#### **6.1 Total Costs**

The resource estimates in assessing a system for its user-interface and selection among a range of different available systems is as follows. The factors under consideration have been shown as different tabulations below. In order to evaluate the system a DSS must be built as has been outlined in the previous sections. The system must be programmed for it to be automated and assist more than one user and more than nominal amount of vendors and attributes/features of each vendor. The cost of building this is followed by the cost of testing the software built for validity of its' results and calculations. There must be a way to then distribute the system to the user community and test it for any unknown bugs and fix them. Here are some calculations about the resource estimates for evaluating the system quantitatively using the DSS.

The cost of building the DSS can be calculated as follows. The DSS in the context of this discussion is the one referred to in section. It must be implemented as a software for the decision maker to evaluate the database-systems/vendors. To recall from the previous section, the decision makers will rate the system on semantic differential scale[22]. The inputs from users are taken by the DSS and it calculates the final ratings for each database-system considering each decision makers' rating. The cost of building the DSS for evaluating the

system is as follows. All costs have been assumed to have been attributed to employees at \$70 per hour. Requirements collection is by system analyst and programming is done by a programmer also at \$70 per hour.

**Table 13** Table for cost of building the DSS

| Description  | Cost in \$ |
|--|------------|
| 1. Collecting requirements 24hrs * \$70/hr                 | 1680       |
| 2. Requirements Analysis 24hrs * \$70/hr                   | 1680       |
| 3. Conceptualizing and designing the DSS 115 hrs * \$70/hr | 8050       |
| 4. Development of scales of the DSS 8 hrs * \$70/hr        | 560        |
| 5. Pilot test of the scale 5 hrs * \$70/hr                 | 350        |
| 6. Functional specification building 32 hrs * \$70/hr      | 2240       |
| 7. Technical specification building 32 hrs * \$70/hr       | 2240       |
| 8. Programming / Application development 115 hrs * \$70/hr | 8050       |
| Total  | 24,850     |

The cost of testing the DSS is as follows. The cost of testing the system consists of checking for errors (due to programming) after the product has been ready for use. These are bugs in the software. There may be miscalculations for the ratings entered by the users. The system may crash which must be tested. There could be possible limitations to the software in ways that the software does not perform as desired. The testing of the software also tests for

users being able to give correct inputs and correct the inputs given. This can generally be done by a tester who is paid \$50/hr.

**Table 14** Table for testing the DSS

| Description   | Cost in \$ |
|---|------------|
| 1. Testing for software bugs 24hrs * \$50/hr  | 1200       |
| 2. Testing validity of scales(if the software does not accept illegal values) 8 hrs * \$50/hr | 400        |
| 3. Testing the DSS for crashes 5 hrs * \$50/hr  | 250        |
| 4. Cost of time for preparing and entering test data 8 hrs * \$70/hr                          | 480        |
| 5. Setting up supplies and equipment (computers, internet connection etc.)                    | 1000       |
| Total   | 3330       |

The cost of testing the software and testing the use of the DSS among users is as follows. The cost of testing and using the software among real users consists of employing potential persons who will really make use of the software. These are persons from the various departments that use the software for (a) the purpose of searching documents in the database-system, (b) assisting users of the database-system, (c) delivering documents to users that do not own the system. Testing includes using the DSS and rating the database-systems various features on the semantic differential scale and entering the number into the DSS. The users are then asked to deliver the files to the administrator who feeds them to the part of the DSS that calculates the final decision matrix. Persons are needed to administer the entire session,

potential users that will use the software and assistants. The costs are calculated as follows. The total cost found was \$ 35,520 ( $\$ 24,850 + 3330 + 7340$ ).

**Table 15** Table for cost of testing software and the use of the DSS among users

| Description  | Cost in \$ |
|--|------------|
| 1. Deploying the system to the users 3 hrs * \$70/hr           | 210        |
| 2. User training 10 employees * 5 hrs * \$70                   | 3500       |
| 3. Building Vendor – Attribute List 3 employees * 3 hrs * \$70 | 630        |
| 4. Administrator for one session 4 hrs * \$50/hr               | 200        |
| 5. Potential users 10 * 4 hrs * \$70/hr                        | 2800       |
| Total  | 7340       |

### 6.1 Perceived Benefits

The perceived benefits due to the use of the DSS are relatively easier to calculate because they are compared to the old method of making decisions by a single person or by a face-to-face decision group. The benefits perceived are saving of time from discussions done in the past. This statistic (of time) is an approximate figure from decision-making discussions held in the past. The other benefit is that of having chosen a database system that were useful to a department rather than the one that is not (which would have been chosen using a face-to-face discussion/individual decision). This is estimated by questioning each department of how many systems that they perceived useful were added or those not useful were removed. The

saving from removing an old system or the benefit (perceived profits from a single system) from adding a new system is calculated. The gross estimate of profits yielded with the choice of the new set of databases is assumed to have been calculated (predicted earnings).

**Table 16** Table for perceived profits and savings (benefits)

| Description   | Cost in \$ / year |
|---|-------------------|
| 1. Time saved 10 decision makers * 32 hrs * \$70/hr                             | 22,400            |
| 2. Removal of old academic database systems – 2 system * \$2,000,000/system     | 4,000,000         |
| 3. Addition of one new academic database system – 1 system * \$2,000,000/system | -2,000,000        |
| 4. Perceived profit from the services of the new system                         | 200,000           |
| Total   | 4,022,400         |

From this the a simple cost/benefit ratio [27] can be calculated as follows:

$$\text{Cost} = \$ 35,520$$

$$\text{Benefit} = \$ 4,022,400 / \text{year}$$

$$\text{Cost/benefit ratio} = 8.83 * 10^{-3}$$

This is a very low cost to benefit ratio or a very high benefit to cost ratio. This means that the profit or benefit incurred from the use of the DSS is very high. If selections are done every year then the following can be deduced. The benefits exceeded costs for the year when

the DSS was built. The next year onwards there will be no development or testing costs. The profits will be calculated based only on the cumulative savings as shown above.

## **CHAPTER 7**

### **CONCLUSIONS**

The solution to making selections is therefore first evaluating the software or system at hand. The next step is to analyze the results of the evaluation. If the evaluation was quantitative then the numbers generated from the evaluation must be assessed. The numerical data generated from the various methods of data analysis must be interpreted correctly. Firstly the data generated from the DSS uses pessimistic averaging. Hence the lowest values are taken into consideration when averaging. The numeric values generated from such an evaluation are considered as absolute for systems being evaluated. A method to assess the advantages or disadvantages of using the DSS as against FTF or an individual evaluation of the system has been shown.

Quantitative evaluations are much preferred in decision making when there is ample of available time to assess the software because the use of quantitative evaluations for much detail oriented work for analyzing systems, such as the use of statistical methods. Qualitative methods are suggested to be used when systems are relatively less complex and easy to use. It has been discussed earlier how the analysis of user-interface can be done using an algorithm to assess each dimension of the interface.

One must bear in mind that for a user-interface evaluation a dimension may not exist and the evaluation may not yield correct results. Hence it is important that all dimensions of

the user-interface analyzed qualitatively. Finally the use of qualitative and quantitative methods  
Finally the use of qualitative and quantitative methods is purely dependent on the problem at  
hand.

## **APPENDICES**

- Appendix A: The Consent Form** - The consent for conducting protocol analysis
- Appendix B: Instructions for the Subject** – Instructions for protocol analysis subjects
- Appendix C: Task List** – The lists of tasks for protocol analysis subjects
- Appendix D: Interview Questions and Subjects for Protocol Analysis** –  
A Post-task questionnaire given to all protocol analysis subjects
- Appendix F: Individual Test Results** – Results of protocol analysis
- Appendix G: DSS output for Decision Maker inputs** – User Inputs during a decision making session with the DSS
- Appendix H: DSS output for Final Decision Matrix** – DSS output in the form of final decision matrix for the systems being analyzed

## APPENDIX A

### The Consent Form

**Project:** A Protocol Analysis for Two Features of the MSN Portal

**Conducted by:** This Protocol Analysis is being conducted by Rohan Pandit, Rakesh Antala and Hiren Butala at New Jersey Institute of Technology, Newark, NJ.

**The system to be analyzed:** The system being analyzed is the MSN Portal which is a publicly available website through the Internet. The Portal is simply a doorway to a world of information.

**Statement of non-commercial use of the study:** Since the nature of the website being analyzed is in public use through the commercial firm Microsoft Corporation it is hereby stated that this study will not be used for any commercial activity. We do not represent, in any way, the Microsoft Corporation. This study is strictly being used for an educational purpose.

**Confidentiality:** I have been told with respect to my participation as a protocol subject that the following tasks will be involved for the purpose of the study

- A. Surfing various parts of the website
- B. Giving an opinion as a website user, about the portal's user interface and other aspects of the MSN portal system
- C. Review various features of the MSN portal system

A protocol subject, such as you, will be able to keep the information recorded during this study, confidential. The recorded interview will be destroyed after the study is over. A subjects' real name shall not be released and any reference to the subject will be made by a mock name.

**Agreement:** I am fully aware of the nature and extent of my participation in the said project. I hereby agree, with full knowledge and awareness of all the afore said to participate in the protocol analysis study. I further acknowledge that I have received a complete copy of this consent statement.

I also understand that I may withdraw my participation from the protocol analysis at any time.

---

|      |                    |
|------|--------------------|
| Name | Signature and date |
|------|--------------------|

---

|                   |                    |
|-------------------|--------------------|
| Researcher's Name | Signature and date |
|-------------------|--------------------|

## APPENDIX B

### Instructions for the Subject

#### **Overview**

Thank you for volunteering to assist with the protocol analysis. The system that has been chosen for this study is the popular msn portal. A portal is a doorway to a world of information. A portal is supposed to be rich with information and is meant to be for just about anybody who wishes to use it. The major functions of a portal are to provide its' audience with a content that is rich in information. A portal may have some of the most common sources of information such as news, entertainment, media, education, special features, search features and a whole range of web features such as games, chat email, online organizers and much more. The system that is being studied as has been said before is the msn portal. The msn portal has a wide range of features including the afore said.

#### **What the user is expected to do**

As a subject to this study you will be expected to do certain number of given tasks. The tasks will be to work with the different features of this portal. The tasks have been predefined for you. These tasks will require the use of standard tools such as a mouse, keyboard, monitor and the computer in order for you to accomplish them. The tasks involve navigating an Internet site for content. During this session you will be verbalizing about what you are doing while you are doing it. This means that while you are clicking on a link to go to the next page you will speak out loud that you are doing so. Another example is when you are lost or not finding your way around the website you would want to say for instance that I'm having a difficulty getting around the site.

#### **Your interaction with the system**

While dealing with the system you are expected to speak out loud each action that you are doing. Though it is not expected that you give a very highly detailed account of what you are thinking, however you should give a clear picture of what you are trying to accomplish and what you are currently doing at every instance. Your interaction with the system is most crucial to the study and hence you are requested to speak up at every point whether it is easy for you to get around i.e. navigate through the site or when it is difficult for you to do so. At times when you are stuck you may ask for help. About how help will be provided is said in the following section named assistance. You will be interacting with the system like you normally do and there is nothing very special or different about how you will do it here.

**Assistance and Communicating with the researcher**

Assistance about how to get around a certain problem will be provided by me. However assistance will not be provided soon as I find that you are stuck. You will be allowed to think for a while and then if you really cannot get through with the task then I will show you how to proceed. This does not mean that I will explain the entire procedure of the task. This also does not mean that you are being tested. The tasks are simple day-to-day activities that one does on the web and hence it will be likely that you will need little assistance accomplishing the tasks.

**About recording the session over tape**

While you are doing your tasks and verbalizing each of your actions I will be recording your voice on the tape. Even our interaction will be recorded. In short the entire session will be recorded on tape. The recorded conversation will be used to later prepare a transcript and analyze your interaction with the system. You will not be identified throughout the presentation report of the study.

**Tell us about the system**

The study is about analyzing the system with respect to responses given by users like you. This is not a test of your knowledge about the system if you happen to know it. This is also not to test your speed of doing the tasks. The study requires you to do your tasks just the way you would have done normally in order for us to evaluate the system correctly. Hence you must tell about the system and what you feel about it as you go. Report any problems that you encounter. Also report anything that you find is unusual. It is therefore best to be as natural as possible and only to keep in mind that you will verbalize clearly as you do your tasks.

## **APPENDIX C**

### **Task lists**

The following is a list of tasks that the user will be doing. There is a certain generality about the tasks that are assigned to the user. Most importantly there are two types of tasks. One set of tasks is to have the user interact with the system and then record the responses received. The user tasks in this category enable to get information about the user interacting with the system, his likes and dislikes about the system, the difficulties he encountered navigating the site. The tasks also enables inputs regarding how the content should be laid out on the portal and how the various links should placed in order for the user to conveniently surf the various sections of the site.

The other section is about personalization. This section enables the inputs regarding what the portal should do in order for the user to accomplish what he wants and customize the page according to his interests. The personalization features give us the perspective of individual behaviors and how a user would like to have his or her preferences set right on a page such as a customized msn home page. The customization of a page allows us to know what the users really would like to see on the page that they would like to add to their personal preferences. Thus it calls for more requirements investigation and thus the improvement of the system for the user. The tasks have been devised as follows to get the maximum possible inputs regarding the system, whether it requires improvement, or redesign.

#### **User interaction with the system**

1. Find the news headlines from the msn front page and surf the headlines. Report your responses about the system.
2. Find the stock quotes from the msn page.
3. Find a topic of your interest from the MSN home page.
4. Pick a highlight and surf it. Tell me you experiences

#### **Personalization**

1. Personalize content by clicking on the change content on the page and selecting the topics to personalize.
2. Personalize layout by clicking on the change layout and positioning the content the way you want.
3. Change the color of home page by clicking on the change color selecting from the set of colors.
4. Navigate through the website by clicking on the link of your choice and return back to home page.

## APPENDIX D

### Interview questions and Subjects for Protocol Analysis

The following are a set of post task questionnaire questions. They are designed to get the user opinion about the overall functioning of the system. About how the user felt the system was, about what he/she felt was confusing and not appropriate that made the part of the system unusable. The interview questions are asked after the user finishes all the tasks and hence has an overall view of the system or the part of the system being analyzed. This is the most crucial part of the study. The responses obtained through this post- task questionnaire are used to suggest improvements or keep the current system up with some or no changes. The responses to these help especially in pointing parts of the system that require extensive redesign and unification with other parts of the system.

The responses also call for considering the system from the user perspective than more from just a design perspective in which user tasks or trails of tasks are usually assumed since at every point of the design the user is not present to give his/her inputs regarding how he/she will do things. This post-task questionnaire is therefore very useful for us to indicate what were the unidentified issues during system design that led the user to a wrong path or were correctly designed and must be kept so that the user will find that functionality each time he visits the system. This also means that the parts of the system that the user felt right must be maintained in the right way and must not be scrapped out to give way to other pieces of functionality or feature. The system has been liked for that feature and must be therefore consistent across time.

#### **Questionnaire for User content Interaction and Personalization of the system**

1. What was most valuable with the system?
2. What was confusing in the system?
3. What was missing in the system?
4. What was not useful?
5. What was the utility of some of the feature interactive highlights encountered in the system?
6. How well the system supports your given tasks?

#### **Subjects**

| Subject | Age | Sex | I. T. Experience | Interest in Web Portals | Researcher    |
|---------|-----|-----|------------------|-------------------------|---------------|
| A       | 23  | M   | Semi-expert      | Yes                     | Rohan Pandit  |
| B       | 24  | M   | Expert           | Less                    | Rohan Pandit  |
| C       | 27  | M   | Expert           | Yes                     | Hiren Butala  |
| D       | 25  | M   | Expert           | Yes                     | Hiren Butala  |
| E       | 31  | M   | Expert           | Less                    | Rakesh Antala |
| F       | 23  | F   | Novice           | Yes                     | Rakesh Antala |

## APPENDIX E

### Individual Test Results

#### **Test Results for subject B (Final)**

##### **Background of the subject**

This subject was an expert web user. He uses most features of the web. Therefore he knows the ins and outs of the web. This subject was even used user interface jargon like functionality and usability to my surprise. According to him he uses the web usually to surf for content, to email his friends and visits new sites very frequently. Thus he has the knowledge about what a web is made of and the various components that go into making the web pages. Therefore it was an interesting experience to have him as a protocol subject to a set of primitive tasks. His comments were also interesting.

##### **Summary of Experience**

This subject knew a whole lot about web pages, portals and their design and pointed out every small aspect of the system where there were misnomers, problems, missing functionality and unusable features in a flash. His experience was pleasant with the system. He encountered a lot of good and bad features, which made the system appear to him as a fairly okay system at times and very good at times.

##### **Positive Aspects of the System**

He found the interface was good and the colors and design used in making the web site was pleasing. On many pages he mentioned of things being in places they should be, like links and menu systems. He mentioned of good content being shown to him. The content was the major focus of the study wherein the user was meant to interact with the content presented to him. That there was satisfaction in viewing the content is a positive aspect of the system, which would not require any redesign or improvement. He found that the entertainment section was good and that he liked the task where he was asked to look for and read movie reviews.

##### **Difficulties Encountered with the system**

He also presented a negative account of the system besides the positive. He mentioned that it was confusing at first to find the news page and he was expecting to find US News but he was led to a page with links that he found confusing. Hence the links on this page were confusing for him. There were bad fonts at places.

### **User Comment and Suggestions**

He mentioned that some links for navigation were named 'next' and 'previous' to lead the page's users to the following or preceding page of content. However he did not like this naming convention and said that they should be changed to something more meaningful in nature such as 'next story' or 'complete story' for a news item. He also found that some pages had streaming media and he would have liked them to be displayed to him via the page itself rather than pop-up windows. He also did not like places in the site where the site requested to personal information. He also noticed that updates on stocks did not occur real time(however this site was not meant to be a stock specialist).

### **Evaluator's Comments and Suggestions**

From observing the user's interaction with the system what he found most appealing was the font and color and layout on many pages. He admitted to have seen good content through the breadth of the site. I would suggest that msn keep up with the good work of providing content that is liked by users such as this subject. Also it is suggested that some web features be laid out in the fashion that user's would perceive right. This calls for fixing site bugs such as avoiding asking for personal information when it is not really necessary, avoiding too many pop-up windows that distract the user and take up system resources on the client's machine. Also it is suggested that the page be up to date for such expert users as this subject.

## APPENDIX F

### DSS Output for Decision Maker inputs

Below is a transcript of a users' session with the DSS. The ratings were placed on a worksheet and data was entered from it into the system. This is the stage where ratings are entered by the decision maker.

```
E:\NJIT\lib paper\read user\input\Debug\paper.exe
*****WELCOME TO THE DECISION MAKING SYSTEM FOR LIBRARY DATABASES*****
M
Enter total number of vendors: 2
Enter the name for vendor 1: ocean
Enter the name for vendor 2: skymount
-----
N
Enter total number of attributes: 2
Enter the name for attribute 1: ill
Enter the name for attribute 2: oclc
-----
Enter total number of decision makers: 2
*--INSTRUCTIONS--*
Enter values from the rating matrix for
the following VENDOR-ATTRIBUTE pairs.
Enter the Decision-Maker number from the top-left of the rating sheet: 1
Writing your input to file RATINGSHHEET1
ocean-ill: 2
skymount-ill: 3
ocean-oclc: 4
skymount-oclc: 5
Verify matrix values. Correct any? y/n? y
Enter row #: 1
Enter col #: 2
Enter new value: 6
Correct another value? n
Enter weight for ill: 6
Enter weight for oclc: 8
D
Verify weight values. Correct any? y/n? y
Enter attr #: 1
Enter new value: 9
Correct another value? n
ocean          skymount
ill   2.00000000  6.00000000
oclc  4.00000000  5.00000000
Enter the Decision-Maker number from the top-left of the rating sheet: 2
Writing your input to file RATINGSHHEET2
ocean-ill: 3
skymount-ill: 4
ocean-oclc: 2
skymount-oclc: 1
writing to file done
Verify matrix values. Correct any? y/n? n
Enter weight for ill: 5
Enter weight for oclc: 4
E
Verify weight values. Correct any? y/n? n
ocean          skymount
-----
```

\*\*\*\*\*WELCOME TO THE DECISION-MAKING SYSTEM FOR LIBRARY DATABASES\*\*\*\*\*

```
Enter total number of vendors: 2
Enter the name for vendor 1: ocean
Enter the name for vendor 2: skymount
-----
Enter total number of attributes: 2
Enter the name for attribute 1: ill
Enter the name for attribute 2: oclc
-----
Enter total number of decision makers: 2
*--INSTRUCTIONS--*
Enter values from the rating matrix for
the following VENDOR-ATTRIBUTE pairs.

Enter the Decision-Maker number from the top-left of the rating sheet: 1
```

```
Writing your input to file RATINGSHEET1
ocean-ill: 2
skymount-ill: 3
ocean-oclc: 4
skymount-oclc: 5
```

```
Verify matrix values. Correct any: y/n? y
Enter row #: 1
Enter col #: 2
Enter new value: 6
Correct another value? n
Enter weight for ill: 6

Enter weight for oclc: 8
```

```
Verify weight values. Correct any: y/n? y
Enter attr #: 1
Enter new value: 9
Correct another value? n
      ocean          skymount
ill    2.000000      6.000000
oclc   4.000000      5.000000
Enter the Decision-Maker number from the top-left of the rating sheet: 2
```

```
Writing your input to file RATINGSHEET2
ocean-ill: 3
skymount-ill: 4
ocean-oclc: 2
skymount-oclc: 1
```

```
writing to file done
```

```
Verify matrix values. Correct any: y/n? n
Enter weight for ill: 5

Enter weight for oclc: 4
```

```
Verify weight values. Correct any: y/n? n
      ocean          skymount
ill    3.000000      4.000000
oclc   2.000000      1.000000
writing to file done
```

```
Enter y at the prompt to exit: y
```

## APPENDIX G

### DSS Output for Final Decision Matrix

Here is an output from the computational module. The final decision matrix is seen the second to last line.

```
5 "E:\ANJIT\lib paper\compute final decision\Debug\readest.exe"
sum: 5
initial min: 3
find min result: 3
over 2.5 pesave: 2.25
initial sum: 6
sum: 9
initial min: 6
find min result: 3
over 4.5 pesave: 3.75
initial sum: 5
sum: 9
initial min: 5
find min result: 4
over 4.5 pesave: 4.25

pmatrix:
1.250000      2.250000
3.750000      4.250000
reading ven rating
rating: 2
rating: 3
done reading ven rating
reading ven rating
rating: 1
rating: 2
done reading ven rating
averat without add: 2
averat without add: 3
averat without add: 3
averat without add: 10
averat: 1.5
averat: 5
initial min vt: 2
find min result vt: 1
pesave vt: 1.25
initial min vt: 3
find min result vt: 3
pesave vt: 4
attr: 1 overst: 2
pmatrix@0 1.25 r.averat@ 1.25
pmatrix@0 3.75 r.averat@ 4

matrix@0 16.5625
pmatrix@1 2.25 r.averat@ 1.25
pmatrix@1 4.25 r.averat@ 4

matrix@0 19.8125
FINAL RATED MATRIX:
19.812500
16.562500

closed RATINGSHEET1
closed RATINGSHEET2
End
Press any key to continue
```

```
opened RATINGSHEET1
opened RATINGSHEET2

pmmatrix:
1.250000      2.250000
3.750000      4.250000

FINAL RATED MATRIX:
19.812500
16.562500

closed RATINGSHEET1
closed RATINGSHEET2
End
Press any key to continue
```

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