EVALUATING DECISION SUPPORT SYSTEMS: A DIALECTICAL PERSPECTIVE

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Abstract

This paper raises a number of issues about the problem of evaluating a (decision) support system used for supporting unstructured and semi-structured problem-solving. The paper proposes a conceptual framework for the evaluation of support systems. This framework is based on an analysis of the evaluation realms, considered in terms of the whole decision-making process. The framework consists of two dimensions: the evaluation criteria and the evaluation object. The evaluation criteria are on a continuum from objective to subjective. The evaluation object consists of three components: the DSS design; the decision-making process; and the decision outcomes. The framework is then utilized to describe a systematic method for evaluating support systems. In addition to the above, a discussion about the implications of the framework and a comparison of predictive (a priori) versus a posteriori evaluation approaches is also included.

I. Introduction

A possible question arising from the fundamental premise that a DSS[1] is developed to support semi-structured [4, 17] and unstructured [27, 21] problems, is: Can a DSS be evaluated? The goal (mission) of a DSS is to provide support so as to improve decision making. Improvement of decision-making is taken by most researchers to mean effective decision outcomes [5, 17, 12, 27]. Since DSSs in general, support unstructured problems, an attempt to evaluate the effectiveness of decision making seems to be in itself a paradox. This results from the existence of no criterion that would determine whether a solution is correct or false [21, 8]. In other words, since there is no deterministic answer to problems that are unstructured or semi-structured, it is impossible to judge whether the solution is correct, incorrect, false or true. "Solutions (of unstructured problems) are judged as good, bad, reasonable, but never correct or false" [21, p. 479-80; 8, p. 350]. Furthermore, a DSS is designed by determining the user's needs and through the establishing of objectives for the system. Thus, if the objectives of the said system are met, the system is effective. This is because the information needs of the user (decision-maker) are appropriately supported by the DSS, who in the first place had stated the objectives for the system. In consequence, the question of measuring the effectiveness of a DSS appears to be unresolvable.

Thus, it appears that there is a need to look into the evaluation problem in more detail, and to identify its important and unimportant aspects. The identification of the unimportant aspects of the evaluation problem will be useful to the extent that they limit and constrain the problem. A dialectical perspective, in an Hegelian sense, involves the proposition of a view that is contradictory, antithetical or at a minimum, questions the underlying assumptions of another view (e.g., an extant view), and culminates in a synthesis of these views to reach the "truth". A dialectic, therefore uses discussion and reasoning by dialogue between opposing views as a method of intellectual investigation [Webster's Ninth New Collegiate Dictionary]. Within the context of this paper, the dialectical perspective of the evaluation of (decision) support systems, exposes certain weaknesses and explores issues relating to the fundamental assumptions, beliefs and contradictions of existing evaluation approaches. In doing so, this paper develops a different, alternate view of the evaluation problem. The dialectic also proceeds at another level. It attempts to contrast "a priori" and "a posteriori" evaluation of DSS. This dialectical perspective on the evaluation of DSS should provide both researchers and practitioners, a better understanding of the evaluation problem and a framework within which to systematically study it. It should also clarify the evaluation paradox stated in the first paragraph of this section.

Consequently, the objective of this paper is threefold:

1. To provide a dialectical perspective on the problem of evaluating support systems (DSS) and analyze the realms of the evaluation problem in terms of the overall decision-making process;
2. To propose and detail an evaluation framework within which the reader can select evaluation criteria; and
3. To describe a systematic method based on a holistic approach for the evaluation of DSS. This is based on the discussion obtaining from the first two objectives.

[1]The term (decision) support system (DSS) used in this paper is taken to mean **any** support system that is used to provide computer-based support to decision-makers involved in solving semi-structured and unstructured problems.

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Although different authors have compared and reviewed various approaches to evaluating information systems [e.g., 16] and decision support or decision-aid systems [e.g., 3, 25], most have not viewed the problem of evaluating DSS from an holistic perspective. The framework for evaluating DSS developed in this paper attempts to provide such an overall, system view of the evaluation problem. In proposing the evaluation problem and studying the criterion for evaluation, this paper will follow a problem-solving/decision-making approach akin to Simon and John Dewey [from 26]: What is the (evaluation) problem? What are the alternatives? What is the best alternative? (Or Is there one best choice?).

Consequently, the paper proceeds as follows. This section (I) gave a broad introduction to the contents of the paper and its objectives. The next section (II) will discuss the meaning of the concepts of evaluation and effectiveness and define them for the purpose of this paper. The third section (III) describes the evaluation problem. The framework for the evaluation of DSSs is proposed in section IV. Section V discusses some implications of the framework, including a comparison of "a priori" versus "a posteriori" evaluation. Based on the framework for evaluation, a systematic method for evaluating DSS is described in section VI. Finally, section VII provides some concluding comments.

II. Evaluation and DSS Effectiveness

Evaluation of a system is an attempt to attach a value to the system. Evaluation must have a purpose--it is not an end in itself [20]. Most authors agree that evaluation of a DSS requires a measurement of the effectiveness of the system [7, 13, 17, 27]. Efficiency, though distinguished from effectiveness by some authors, is a subset of the decision support system effectiveness. DSSs are designed to aid in decision-making and decision implementation, and are oriented toward the overall effectiveness of organizations and individuals [4, 14, 17]. There have been numerous empirical studies that have examined DSS effectiveness and have shown inconclusive results, i.e. DSS vs. non-DSS decisions have shown no significant difference[2].

Anthony [5, p. 27] asserts that "effectiveness relates to the accomplishment of the cooperative purpose. . . . When a specific desired end is attained we shall say that the action is effective". A system is a set of interconnected components that work together for a purpose [6]. The purpose of a DSS is to improve decision-making through the provision of support that is reliable, accurate, timely, and of good quality [2, 11]. The system consisting of the user and the DSS, will in turn be effective if both work toward the cooperative purpose of improving decision-making.

Therefore, **effectiveness** is a desired result, outcome, consequence, or operation [6, 15]. And, **system effectiveness** is a measure of the ability of a system (in this case the decision-maker and the DSS) to accomplish its objectives or mission. It is a measure, in a predictive sense, of the extent to which a system can be **expected** to achieve a set of specified goals [15].

III. The Evaluation Problem

In examining the evaluation problem, it is useful to answer the following questions [9,20]: Can DSS be evaluated? (or Why measure DSS effectiveness at all?). What is being evaluated? (or What should one measure?). The first question will be discussed in this section, and the second question will be addressed in the next section.

It is argued that DSSs cannot be evaluated because they provide support for novel and unstructured or semi-structured problems[3]--thus there are no **base** decisions with which to compare [27]. In other words, since unstructured and/or semi-structured problems are not deterministic, a "best" or "optimal" answer is not known. If it was required to evaluate a system that supported structured problems, one could definitely say that evaluation would be simple. For example [11], the problem of determining the inventory reorder quantity is easily solved by using a model for calculating the EOQ, and then determining the reorder quantity. The solution of the problem did not involve the decision-maker except perhaps to enter inputs to the system, which then produced the inventory report(s). Evaluation of such a system would involve determining whether the system is effective in terms of resource usage, timeliness, its mean-time to failure, and so on. These measures mostly relate to the design of the system--its hardware, software, and other similar facilities. Of course, a pragmatic manager would obtain such a system, simply because of the ability to see a real dollar advantage that far exceeds the cost of acquiring such a decision-aid. Thus, the evaluation of systems that support structured problems is relatively uncomplicated.

When one considers that DSSs are utilized for support in solving semi-structured and unstructured problems, the question of evaluation becomes much more tricky. It is the view of this author that measuring effectiveness of DSSs is a non-issue. A big stumbling block seems to be the "word" measurement [2, 9]. Both, practitioners and researchers are guilty of suggesting that there should be (or will be) a formula that will accurately relate DSS effectiveness and improved decisions in terms of profits and such hard dollar savings [18, 8] on the one hand, and decision quality, decision-confidence [1, 8, 3] on the other. Those who expect to find such a formula will,

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[2]For a comprehensive review of the theoretical and empirical literature on different evaluation approaches for measuring information systems effectiveness, the reader is referred to Hamilton & Chervany [16], Sharda, et al. [25], Aldag & Power [3], and Adams, et al. [1].

[3]It should be pointed out that the terms "unstructured problem" and "semi-structured problem" are being used in the manner defined by Gorry and Scott Morton [1971] in their seminal paper describing a framework for management information systems.

with a few rare exceptions, be disappointed [9]. But, the answer to the question, "Can the effectiveness of a DSS be evaluated?" is unreservedly "Yes". Every DSS can be evaluated in relation to its objectives (system purpose), that were set for it at the outset, and as an ongoing process of evaluation through the design and implementation stages of the DSS development [19]. One possible solution is to use prototyping as the method for system development. In that case, the evaluation problem is easier, in the sense that the sunk costs are not as high as in the case of a full fledged DSS which ultimately does not meet performance specifications. This statement underscores the fact that once a "full" system is purchased or built and found to be ineffective, it will require additional expenditure for modifications and/or additions to bring it (the DSS) to the level of performance initially envisioned. Whereas, in using the prototyping method for system development, there exists an ability to evaluate the system in a phased fashion--thus, any major investment to build a full fledged system is delayed till the prototype is found to have met performance specifications. Furthermore, in the case of a prototyping approach for system development, the evaluation of the DSS in terms of its objectives is simplified--one can decide whether or not to go for the full system at any stage in this iterative development process.

Thus, the problem of evaluation relates to understanding the objectives of the DSS and measuring effectiveness of the DSS in terms of these objectives. The user will have to provide, a priori, a definition of what is meant by improved decision-making or increased effectiveness of decision-making [17]. One may argue here that since the problem being supported is unstructured, and one does not have a deterministic program, what would be evaluated? A possible answer is that, system effectiveness is measurable once the general problem domain is specified, and certain overall objectives (purpose) for the DSS are established--such as the performance criteria, the models that should be available, the database management system, the user-interface, and the other components of a DSS [13]. In addition, the system objectives that relate to DSS use by the decision-maker should also be specified. This approach would allow the testing of simulated problems taken from actual situations in the past. Consequently, comparisons can be made between decisions made with DSS use, and a **base decision** from the past within the same problem domain.

IV. Framework for the Evaluation of Decision Support Systems

Different authors have suggested many alternative approaches that can be used for the evaluation of DSS effectiveness. The literature on evaluation of DSS effectiveness is divided on the question: what should be used to make an evaluation? (or what is being evaluated?). The problem with extant evaluation approaches has been that, some authors are measuring system effectiveness in terms of the support for the decision-making **process** [1, 28], others are measuring the effectiveness of the DSS **design** [3, 5, 11, 17, 18], and still others consider it in terms of the decision **outcomes** produced as a result of the DSS use [8, 9, 19, 22]. Thus, a framework for evaluation of DSS is essential to providing the manager and/or researcher an organized perspective of the evaluation problem.

Prior to describing the framework for the evaluation of decision support systems (DSSs), it is useful to examine the concept of "evaluation of a DSS", and how it fits into the whole process of decision-making, starting from receiving of inputs by the total system (user+DSS), to producing and implementing the decision. Figure 1 describes the DSS operation in its simplest form. Inputs are obtained from the real environment (the problem space)--these may be for example, information about the competition, the success of a certain strategy in the past, the corporate database accessible to the DSS, and so on. These inputs are then used by the system (the user and the DSS working together) to produce certain outputs. These outputs are characterized as the results of the interaction between the user and DSS. These may be generated alternatives on the one hand, and perceptive results such as user-satisfaction, decision confidence on the other end of the continuum. The outputs are then studied and the feedback produced is used to modify the inputs to the system. This DSS operation can be further expanded into a picture of the realms involved with the evaluation of a support system (see Figure 2).

The term **realm** is synonymous with the domain of reality that affects the evaluation of a system at different stages of the decision-making process. The **realm of reality** consisting of the environment, both internal and external to the company, and the problem domain, is filtered by the decision-maker to produce inputs about the problem space. The filter may be considered to be a part of the **user** to a certain extent. These inputs are used by the decision-maker to interact with the DSS. This evaluative portion of the reality is very subjective, and falls into the category of the **subjective realm** [16, 23, 26]. In this realm any measurements that can be made about the quality of inputs, the relevance of the information, etc., are all purely subjective--in other words, are difficult to quantify [23]. The user and the DSS working together (as a system) generate alternatives. These alternatives fall into the **system realm.** Here, the evaluation problem is concerned with viewing the DSS from a design perspective. Effectiveness measures for this realm relate mainly to design criterion that can, in general, be quantified. Questions such as, does the DSS meet design specifications?, or is the user a competent decision-maker?, are of interest in the system realm. After generating alternatives, the decision-maker uses the DSS to determine the "best" alternative and then makes a choice, and implements the selected alternative [26]. The generation of alternatives and the choice of a best (in the view of the decision-maker) alternative fall into the **decision-making realm.** Here, the effectiveness measures are more process-oriented and involve examining the number of alternatives generated, the quality of the decision, decision making efficiency, and so on [1, 3, 8]. Finally, the implementation of the decision results in decision outcomes. **Decision outcomes** are the net result

FIGURE 1: THE DSS OPERATION

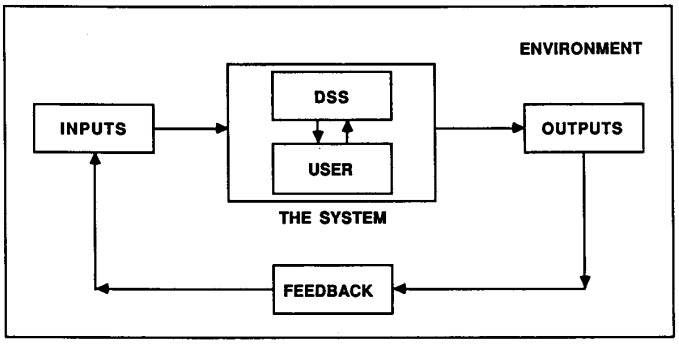


FIGURE 2: THE EVALUATION REALMS

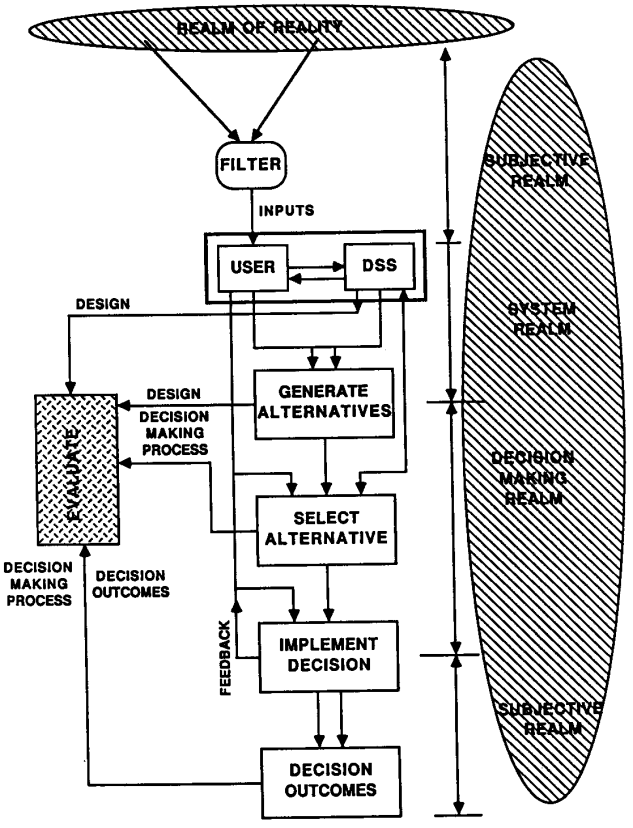
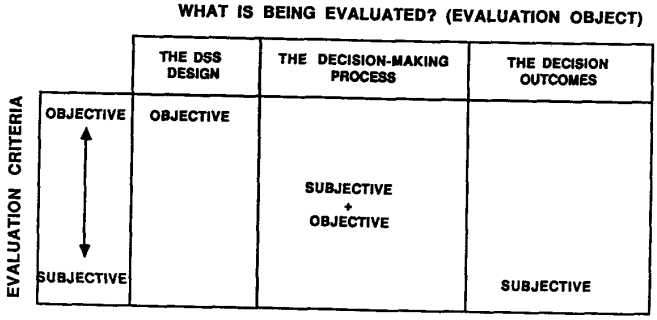


FIGURE 3: THE EVALUATION FRAMEWORK



of the behavior of the symbiotic system for the identified problem. This once again falls into the **subjective realm**, because the outcomes are mostly perception-oriented in nature--in view of the fact that DSSs support unstructured and/or semi-structured problems. Consequently, it would generally be impossible to specify criteria that will help determine with certainty, whether the outcomes of the decision are the "best" or "optimal". The only determination that can be made without being incorrect is the fact that in the opinion (or perception) of the decision-maker, the decision outcomes are better than those that would have been made in the absence of the DSS. For example, one could ask questions such as: is the decision-maker confident about the decision?, or is the decision-maker satisfied with the DSS?, or is the decision better relative to the decisions made without the DSS?, and so on.

The **framework for evaluation** (Figure 3) incorporates the above notions for resolving the evaluation problem. On one dimension of the framework is the **evaluation criteria** as a continuum from **objective** to **subjective**, and on the other dimension is the **evaluation object**. The use of the terms subjective and objective is not new; these have been used by Hamilton and Chervany [16] to classify extant evaluation approaches. The difference is in the application of the terms and not their meaning. The framework proposed here uses the **continuum** from objective to subjective to specify evaluation criteria for a given evaluation object. The evaluation object is further sub-divided into three components: **The DSS design, The Decision-Making process,** and **The Decision Outcomes**. The inclusion of the evaluation object in this framework helps answer the query: what should be used to make an evaluation? (or what is being evaluated?). This also clarifies some of the confusing results that researchers have obtained from empirical studies conducted on DSS effectiveness. The problem with many of the empirical studies on system effectiveness has been that, although their "object" of evaluation is the system (user+DSS) effectiveness, they have measured a mix of things that relate to different realms of evaluation, from decision quality to increase in profits.

The evaluation realms suggest the classification of evaluation objects into the three categories defined earlier. The criteria for the evaluation object "The DSS design" are relevant to aspects of the computer system's development and maintenance, and can generally be easily quantified. The "decision making process" object requires a set of criteria that are a mix of subjective and objective criterion. These would examine the actual decision making process (see Figure 2) and measure the effectiveness of the system as one symbiotic unit. Finally, the "decision outcomes" object require analyzing the subjective measures related to the result(s) of the decision. These are akin to the "feel good" type of measures and are generally perceptive in nature. Some measures for each of these evaluation objects are categorized into a set of subjective-objective evaluation criteria, and exemplified in Table 1. The table (Table 1) is based in part on the evaluation measures used (or proposed) by various authors [1, 2, 3, 8, 10, 11, 12, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 27, 28]. These measures are meant to be suggestive of the type of criteria that can be utilized to evaluate (decision) support systems. The most important aspect is the recognition of "what is being measured", or from "which effectiveness perspective" is the evaluation problem being approached.

V. Is there one simple solution? (Other implications of the Framework)

There appears to be no simple solution to the evaluation problem. It was argued in an earlier section (III) of this paper that it seems fallacious to believe that one single neat formula or model can be developed to measure effectiveness of information (support) systems, and DSSs in particular. The framework described in the previous section confirms this assertion--the framework implies that there is **no singular** solution to the evaluation problem. The important conclusion is to realize that evaluation can be done, and that the object of evaluation should be matched with the criteria used for the evaluation. Irrespective of whether the criteria used are objective or subjective, the task of evaluation is

TABLE 1: THE EVALUATION FRAMEWORK

Evaluation Criteria	Evaluation Object: The DSS Design	The Decision-Making Process	The Decision Outcomes
Objective	Response time Availability Mean-time-to-failure Training costs Validity-of-design Reliability System readiness Design adequacy	Decision time Number-of-analyses-done (Number-of-models-used) Number-of-alternatives-examined (Productivity) Cost savings Capability -of-models-used	
Subjective		Confidence-in-prediction Decision-efficiency Process-structure Process-adequacy Quality-of-user-interface	Decision-performance Satisfaction Decision-quality Problem-understanding (Problem-knowledge) Confidence-in-solution Relevance-of- information- produced

simplified if, a priori, the nature and characteristics of the object under consideration are established. Comparisons should be made with respect to these established measures, based on the goal of evaluation.

Another important implication of this framework is the conclusion that to obtain a holistic view of the evaluation problem, it is necessary to start with its components. Thus, using the framework of evaluation, one could evaluate the effectiveness of each evaluation object. Then, the effectiveness of the components (i.e., each of the evaluation objects) should result in the determination that the system (user+DSS) is effective. That is, the system would be more effective than the sum of its component parts--which are themselves effective [6].

A Priori (predictive) vs. A Posteriori Evaluation

Although this section appears to be a digression from the theme established in the previous sections, it adds another perspective to the dialectic initiated in the introductory passages of this paper. The question of a priori (predictive) vs. a posteriori (after the system has been developed and used) evaluation is an important one. The importance of effectiveness measurement is diminished by the inability to decide, a priori, whether a system (user and DSS) would be effective as a whole. Thus effectiveness, a measure of the ability of the system to accomplish its objectives, should preferably be a predictive measure [23, 29].

In other words, **effectiveness** can also be defined as the **probability P(se)** that the total system will achieve its objectives. The term "total system" means the DSS and its constituent components taken in conjunction with the user with his/her own individual characteristics, interacting together for a purpose (to diagnose, analyze, and solve a problem). Some authors utilize an analytic framework to measure system effectiveness, especially in connection with the a priori evaluation of weapon systems [e.g., 15].

Thus, consider that **P(sr)** is the probability that the total system is ready to operate at any point in the time horizon on demand, and operates satisfactorily under specified conditions (system reliability); and that **P(r)** is the probability that the system will operate under stated conditions without malfunctions for the duration of the decision-making process (system readiness); and that **P(da)** is the probability that the system will successfully accomplish its objectives, provided that it is run within its design specifications (design adequacy). Then, the relationship among these probabilities can be given by the equation [15]:

$$P(se) = P(sr) * P(da) * P(r)$$

It should be noted here that the individual subjective probabilities P(sr), P(da) and P(r) are not truly independent. This framework provides the ability to form, a priori, a judgment about the effectiveness of a system. Though this analytical framework cannot be easily adopted to DSS evaluation, it gives an indication of the advantages and difficulties associated with using a priori vs. a posteriori evaluation frameworks. In the absence of a system (a priori evaluation), the problem of forecasting each of the subjective factors that will ultimately determine the probabilities in an analytical framework such as the one discussed here, is complex. Obviously, one approach is to use past experience with similar

systems [25]. But, this is inherently problematic, especially because of the fact that DSSs are designed for semi-structured and/or unstructured problem domains.

It would seem that knowing a priori, at least to a certain level of "certainty" about the future effectiveness of a system, would be very useful to most practitioners. On the other hand, if proper objectives and measures are established before beginning the development process, and if a systematic development approach is adopted, it could be possible to evaluate systems in their **entirety** with a combination of objective and subjective measures. Also, if a prototyping approach is adopted for system development, it would seem more fruitful to use a phased and systematic evaluation method based on the framework described in the previous sections.

VI. A Systematic Method for the Evaluation of DSS

A holistic view of the evaluation problem should utilize a systematic method. This section uses the concepts developed in the previous sections of this paper and proposes such a method for evaluating DSS. The fundamental presumption being that when one is evaluating DSS, one is attempting to measure the effectiveness of the total system. Thus, it is important to reiterate that the effectiveness of each individual evaluation object implies the effectiveness of the system.

The steps in the following systematic method of evaluation are simple and iterative, and have been stated, at times, in the form of a question.

1. Select evaluation object. (What is being evaluated?)

   - The Total System (User+DSS)
     - The DSS Design
     - The Decision Making Process
     - The Decision Outcomes

2. Select the evaluation criteria (What are the evaluation criteria?).

   If the evaluation object is the system, then criteria for all the three evaluation objects are to be selected. Otherwise, the criteria related to the evaluation object under consideration are to be selected.

3. Establish threshold values for each of the evaluation criterion.

4. Compare each set of criteria with the threshold values.

If an evolutionary or prototyping development approach is utilized, the above method is still valid. But, in that case, in addition to the two dimensions specified in the framework for evaluation, a third dimension comes into play. This third dimension is temporal in nature--since a staged development approach will require an iterative staged evaluation method. The **temporal dimension** relates to evaluation criteria such as user learning over time, user-satisfaction over time, change in confidence over time, and so on. Therefore, in addition to the evaluation criteria obtained from the two dimensional evaluation framework, these evaluation criteria are also applicable to the measuring of the effectiveness of the system (user+DSS).

VII. Conclusions

This paper raises a number of issues that are critical to the problem of evaluating a (decision) support system using system effectiveness as the measure. It seems a difficult and at times tenuous problem to formulate, let alone solve. But the arguments given in this paper shed some light on the problem of evaluating DSSs designed to provide support for unstructured and/or semi-structured problem-solving. It is not truly possible to determine if a system is effective, if the components of the system are evaluated independently. The sum of the parts is greater than the whole, but only to the extent that the criteria for evaluating the parts are not used to make judgments about the whole system (user+DSS). More importantly, the "evaluator" must exercise caution in using evaluation measures that do not produce any real advantage. The recognition of what is being evaluated (the evaluation object), and the corresponding measures or criteria being used for the evaluation (the evaluation criteria), should go far toward resolving the evaluation problem and reaching a better and more effective solution.

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