Revisiting DSS Implementation Research: A Meta-Analysis of the Literature and Suggestions for Researchers

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Abstract

Information systems are becoming increasingly critical to the daily operations and success of many firms. This, combined with the rising investments in design and development of these systems, make implementation a high priority research topic. Although information systems implementation has been a topic of interest to researchers over the past two decades, the extent to which the existing body of research reflects substantial and cumulative development is not entirely clear.

The objective of this study is to conduct a rigorous and quantitative review of the empirical DSS implementation literature as a basis for providing guidelines for implementation management and conduct of future research. Meta-analysis of 144 findings from 33 studies indicates that user-situational variables (involvement, training and experience) are more important than psychological factors to DSS implementation success and that user-situational variables can improve the implementation success by as much as 30 percent. Furthermore, the meta-analytic findings regarding the methodological characteristics of studies provide useful insights for the design of future research studies of implementation. The findings also allow us to put into perspective the incremental contribution of additional substantive and empirical studies in this area. Additionally, several specific domains (e.g., construct validation research on user involvement and casual modeling) might profit most from future research efforts.

Keywords: Decision support systems, implementation

ACM Categories: H.1.2, H.4.2, J.1

Introduction

Information systems implementation has been a topic of interest to researchers over the past two decades. Implementation remains a high priority research topic for the following two reasons:

1. Both corporate investments in and reliance on information systems have significantly grown over the past two decades. Such systems have been used for competitive advantage, establishing direct electronic links with customers and suppliers, enhancing organizational planning and decision making, and reducing costs of business operations and transaction processing. As information systems become increasingly intertwined in the operations, products, strategies, and infrastructure of corporations, it is critical that implementation be successful. However, despite the proliferation of computers, the implementation of these systems remains a complex issue (Ginzberg, 1981; Lucas, et al., 1990; Tait and Vessey, 1989).
2. Reviews of information systems implementation research (DeSanctis, 1984; Dickson, 1981; Ives and Olson, 1984; Vasarhelyi, 1973) have revealed that collectively, implementation studies have yielded conflicting and somewhat confusing findings. These reviews highlight faulty research designs and inconsistency of findings. Thus, the extent to which the existing body of research reflects substantial and cumulative development is not entirely clear.

The objective of this article is to conduct a rigorous and quantitative review of the empirical implementation literature as a basis for providing guidelines for implementation management and conduct of future research. The significance of this study lies mainly in that it provides an opportunity to pause and reflect upon both what has been accomplished by past implementation research and what needs to be accomplished in the future. As such it may help researchers direct their efforts in the most productive manner.

Several types of information systems exist: transaction processing, management information systems (MIS), and decision support systems (DSS). Different systems lead to different utilization patterns, and implementation researchers have distinguished between mandatory and voluntary system usage (Lucas, 1975; Lucas, et al., 1990). Many, if not all, transaction processing systems fall under the "mandatory use" category. Decision support systems, on the other hand, are voluntary; the user many choose not to work with the system. Although implementation considerations are important for all types of systems, this article focuses on DSS implementation. Decision support systems have grown at an accelerating rate over the last decade in response to increasingly complex decision environments. For example, in the five-year period between 1981 and 1985, the number of reported DSS implementations more than doubled from the previous five-year period (Eom and Lee, 1990). And yet, the expected benefits of decision support systems are frequently unrealized (Eom and Lee, 1990; Ives and Olson, 1984; Keen, 1981). As voluntary systems, DSS implementation failures result in the system not being used or being underutilized. Consequently, organizational return on DSS investment tends to be low to marginal and, at times, negative. This study was therefore undertaken to achieve a systematic and comprehensive integration and assessment of DSS implementation research by using the meta-analytic techniques of Glass, et al. (1981) and Hunter, et al. (1982) to:

1. Aggregate findings across a large set of empirical studies to indicate what knowledge has been accumulated on factors thought to influence DSS implementation success, and
2. Investigate the potential impact of the methodological characteristics of the studies on the findings.

While the advantages of qualitative meta-analytic reviews have been well-documented (Glass, et al., 1981; Hunter, et al., 1982), a few features of our work are noteworthy:

1. The research findings were corrected for sampling and measurement errors, thus providing a more accurate picture of the relationship among the variables of interest.
2. Our work provides insights into methodological issues that are useful in developing guidelines for directing future inquiry in the field in terms of choice of subjects, measurement approaches, research setting, etc.
3. Our work establishes the relative importance of different factors to DSS implementation success and identifies the domains that can benefit from additional research studies.

In providing an opportunity to pause and reflect upon what has been learned from past work as well as what needs to be accomplished in the future, this study provides an important milestone toward a cumulative research tradition in the information systems field.

Research Framework and Variables

A large body of DSS implementation studies have investigated the relationship between user-related factors and implementation success. The framework in Figure 1 encompasses different perspectives and common themes from the previous work in the DSS implementation genre. The core of the framework consists of four sets of user-related factors believed to influence DSS implementation success: cognitive style, personality, demographics, and user-situational variables. The relationships between these factors and DSS implementation are believed to be influenced by a number of contextual variables consisting of decision-making tasks, (e.g., task type or task complexity), organizational factors (e.g., top management support), and external factors (e.g., competitive considerations). Although the potential moderating effects of the contextual variables are recognized at a conceptual level, the empirical studies of user factors and DSS implementation are rarely inclusive of all the variable sets displayed in Figure 1. Therefore, our meta-analytic study was organized around the core relationships between user factors and DSS implementation success.

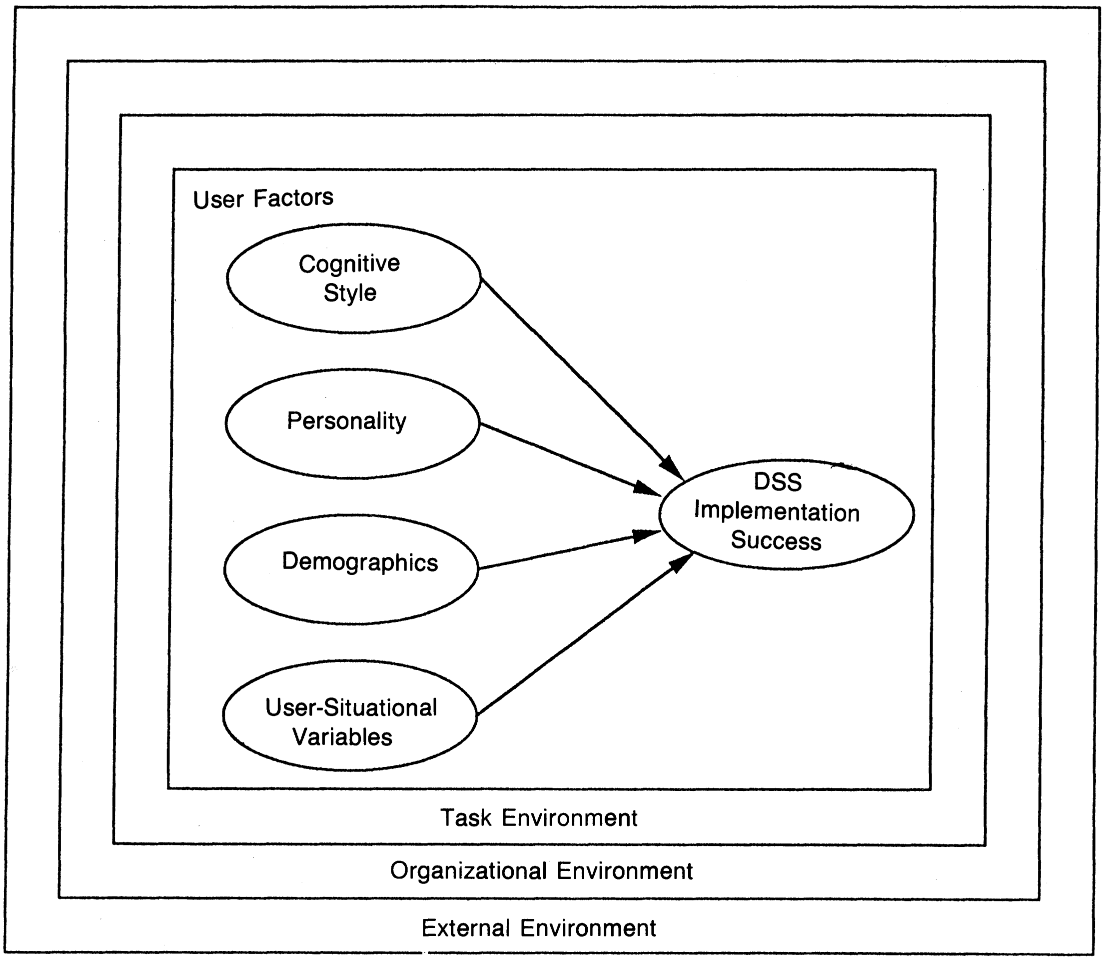

Figure 1. User Factors/DSS Implementation Research Framework

In the next section, DSS implementation success variables and each of the four categories of user factors are discussed. Then, the meta-analytic approach is described. Finally, the meta-analytic findings and their implications for future research are discussed.

DSS implementation success variables

Implementation success refers to realizing the intended benefits of the DSS (Zmud and Cox, 1979). As no single approach to the definition of DSS implementation success currently exists in the literature (Goodhue, 1986; Lucas, et al., 1990), this construct has been represented in terms of a variety of different variables, such as system use, decision-making performance (decision cost or profit), decision-making time, user satisfaction with the system, user confidence in the decisions, and user attitudes toward DSS.

User factors

Cognitive Style

The consensus among theorists who have approached cognitive style from a variety of disciplines is that, at a general level, it relates to the characteristic (habitual) ways individuals process and utilize information—that is, how they solve problems and make decisions (Goldstein and Blackman, 1978; Huysman, 1970). Although cognitive style is a multidimensional construct, most DSS research tends to focus on the analytic/heuristic dimension, which reflects an individual's preference for either utilizing abstract models and systematic processes or relying upon experience, common sense, and pragmatic approaches (Vasarhelyi, 1973; Zmud, 1979a). Approaches that have been used to measure the analytic/heuristic dimension in DSS research include: Vasarhelyi's test; Barkin's Type I/Type II approach; and the Embedded Figures Test (EFT) instrument. Vasarhelyi's (1973) test is based on earlier research by Mock, et al. (1972) and on the description of style behaviors of analytic and heuristic reasoning as presented by Huysman (1968). Barkin's approach is based on a cognitive style paradigm in which individuals are classified along a continuum, with the Type I, or "trial and error," individual at one extreme and the Type II, or "quantitative," individual at the other. The EFT instrument accommodates the classification of individuals along a continuum from low analytic to high analytic.

Another conceptualization of cognitive style prevalent in the DSS literature is based on the Jungian problem-solving style as operationalized by the Myers-Briggs Type Indicator (MBTI) (Myers, 1975). The MBTI consists of four scales that purportedly measure: Extraversion-Introversion (EI); Judging-Perceiving (JP); Sensing-Intuition (SN); and Thinking-Feeling (TF). Each scale is constructed such that the psychological types (e.g., thinking vs. feeling) represent opposite ends of a continuum. The thinking-feeling and sensing-intuition scales are generally believed to represent individual problem-solving and decision-making processes.

Personality

Personality refers to the cognitive and affective structures maintained by individuals to facilitate adjustment to events, people, and situations (Gingras, 1977; Gough, 1976). Personality traits believed to impact DSS implementation success include: need for achievement; degree of defensiveness; locus of control; dogmatism; and risk-taking propensity (Gingras, 1977; Zmud, 1979b).

Demographic Variables

A range of personal characteristics of users, such as age, sex, and education, has been shown to influence DSS implementation success in terms of system use, decision performance, and decision-making time (Benbasat and Dexter, 1982; Mock, et al., 1972; Taylor, 1975).

User-Situational Variables

In our framework, user-situational variables include training, experience, and user involvement. *Training,* in the context of DSS implementation, refers to the provision of hardware and software skills sufficient to enable effective interaction with the DSS under consideration. *Experience*, in a broad sense, refers to prior exposure to decision support systems as well as to the individual's work history (e.g., number of years in a job position). *User involvement*, according to Swanson (1974), corresponds to the "entanglement" of the user in DSS-related activities. Thus, a user and a DSS—two purposeful systems—are "involved" to the extent that the activities of each facilitate the attainment of the ends of the other.[1] In this context, involvement refers to user participation in DSS design and implementation activities.

Method

Thirty-three studies performed between 1975 and 1988 that focused on relationships between user factors and DSS implementation success variables were identified and included in our meta-analysis (see Appendix A for the bibliography of these studies). These studies were located through several literature searches involving bibliographies of existing work and literature reviews, and bibliographic databases including ARTMIS, NTIS, and Social SciSearch. Because journal articles tend to show higher magnitudes of effects than other sources such as working papers, dissertations, and conference proceedings, an effort was made to locate as many studies as possible from sources other than journals. This is because limiting reviews to journal articles can bias the results because less-significant findings are generally more difficult to publish in journals. Consequently, our meta-analytic findings provide a more objective assessment of the strength of relationships between variables of interest than could be discerned from a review of journal articles alone. Additional rele-

[1] This definition adopted from Swanson (1974) is derived from Russell L. Ackoff and C. West Churchman.

vant studies were identified by examining the literature of academic disciplines other than MIS (e.g., marketing and accounting). Characteristics of the studies included in the meta-analysis are displayed in Table 1.

Coding strategy

The studies were independently read and coded by three researchers (the two authors and a research assistant) on the basis of three types of variables: user factors, DSS implementation success variables, and study characteristics. Variables coded from studies are displayed in Table 2. To ensure uniformity, consistency, and completeness, data were recorded on predesigned coding sheets. Disagreements were resolved through discussion after a review of each paper by the group. Agreement among the researchers was high, with initial unanimity occurring in 87.6 percent of the papers. Papers were coded and discussed in batches of five to avoid fatigue. The researchers coded a total of 144 findings from the 33 studies.

Meta-analytic procedures

Meta-analysis refers to a set of procedures for the quantitative acummulation and analysis of descriptive statistics across studies without requiring access to original study data. The basic techniques where pioneered by, and receive their impetus from, Glass, et al. (1981), Rosenthal (1984), and Hunter, et al. (1982).

In meta-analysis, the findings of studies are treated as the unit of analysis. Because the findings across studies were based on different statistical tests (e.g., F-test or T-test), they were converted to a common metric, specifically the effect size index *d*, which represents the effect of an independent variable on the dependent variable.

The effect size index *d* is calculated as follows:

$$d = \frac{\overline{X}_1 - \overline{X}_2}{SD}$$

where $\overline{X}_1$ and $\overline{X}_2$ are the dependent variable means of the experimental groups, and SD is the average standard deviation of the two groups. For example, if group 1 is a treatment group that received DSS training, and group 2 represents a control group that received no DSS training, $\overline{X}_1$ and $\overline{X}_2$ represent the average profits achieved by the groups in the study. When means and standard deviation were not reported in a study, other available computational formulas for the *d* index (Glass, et al., 1981; Hunter, et al., 1982) were used. Cohen (1977), in describing effect size as the degree to which the null hypothesis of no relationship between the independent variables and the dependent variable

Table 1. Characteristics of Studies Included in Meta-Analysis

Sources of Studies (%)	
Journal	64
Dissertation	12
Conference Proceedings/Working Papers	24
Type of Subjects in Studies (%)	
College Students	61
Organizational Members	38
Both	1
Type of Setting (%)	
Laboratory	82
Field	18
Total N of Studies	33
Total N of Subjects	2,082

is false, suggests that an effect size of $d = .2$ constitutes a small effect, an effect size of $d = .5$, a medium effect, and an effect size $d = .8$, a large effect. After being computed, the effect sizes were combined across studies. Multiple findings from a single study of the same relationship (e.g., the relationship between cognitive style and DSS performance as measured in terms of decision-making time and profitability) were combined according to a procedure adopted from Strube (1985). Separate meta-analytic calculations were performed for each of the dependent variable sets (DSS performance and attitudes toward DSS) and the strength of relationships was estimated via the statistics displayed in Table 3 and described in Appendix B.

Results

The meta-analytic findings are reported in the following subsections using the indicators displayed in Table 3. We present findings related to DSS performance first, followed by findings related to attitudes toward DSS, and conclude with a presentation of findings pertaining to an exploratory analysis of study characteristics that moderate the relationships between user factors and DSS performance and attitudes.

DSS performance

Cognitive Style

Fifty-one study findings included in the meta-analysis deal with the relationship between cognitive style and DSS performance. The weighted, unbiased estimate of effect size of this relationship, as shown in Table 4, is $d_u = .246$, and the attenuation-corrected mean effect size of the relationship $d_a = .286$. Actual effect sizes range from -.116 to .943. The sample estimate of total variation among effect sizes for the cognitive style-DSS performance relationship is

Table 2. List of Variables Coded and Included in the Meta-Analysis

User Factors	DSS Implementation Success Variables	Research Methodology Characteristics
Cognitive Style • Analytic/heuristic • Jungian problem-solving style	Performance Variables • Cost/Profit • Decision-making time	Subject Type • Student • Non-student
Personality Attributes • Risk-taking propensity • Dogmatism • Locus of control • Need for achievement • Tolerance for ambiguity • Anxiety • Evaluation of defensiveness • Incongruity adaption level	Attitudes/Perceptions • User satisfaction with DSS • Confidence in decisions • Perceived usefulness of system	Research Approach • Laboratory experiment • Field study Measurement Approaches • GEFT (EFT) instrument • Myers-Briggs Type indicator • Vasarhelyi's test • Barkin's Type I/II instrument
Demographic Variables • Age • Education • Sex		
User-Situational Variables • Experience (DSS and work) • DSS training • User involvement		

Table 3. Indicators Used to Investigate the Strength of Relationships Between User Factors and DSS Implementation Success

Statistics	Description	Formula
d_u	The weighted, unbiased estimate of effect size	$1/\Sigma w_i[\Sigma w_i d_i]$, $w_i = 2N_i/8 + d_i^2$, N_i is the sample size of study i
d_a	Attenuation-corrected mean effect size	$d_a = d_u/[\sqrt{rel_x}\ \sqrt{rel_y}]$, rel_x = Reliability estimates of independent variable rel_y = reliability estimates of dependent variable
S_d^2	Total population variance δ^2	$S_d^2 = 1/N[\Sigma N_i(d_i - d_u)^2]$, $N = \Sigma N_i$
S_e^2	Variance due to sampling error δ^2_e	$S_e^2 = 1/N[K(1-d_u^2)^2]$
S_c^2	The corrected variance of the mean effect size δ_e^2	$S_c^2 = S^2_d - S_e^2$
Credibility interval	95% credibility interval for d	$d_u \pm 1.96^* \sqrt{S_c^2}$
$N_{fs.1}$	The fail-safe N	$N_{fs.1} = [K(d_u - d_c)]/d_c$, K = number of findings in meta-analysis

$S_d^2 = .044$, of which about 32 percent is attributable to sampling error. The credibility interval for *d*, after subtracting sampling variation, ranges from -.031 to .523. This credibility interval suggests the effect magnitudes that will likely be realized in future studies that attempt to predict DSS performance with cognitive style.

Twenty-eight of the cognitive style-DSS performance findings correspond to the relationship between the analytic/heuristic dimension and DSS performance. Average effect sizes for this relationship are higher than those associated with the relationship between the general category of cognitive style and DSS performance ($d_u = .274$, $d_a = .309$), and sufficient information was provided in the reports to allow effect sizes to be corrected for restriction of range. The restriction of range-corrected unbiased mean effect size of .334 suggests that of all cognitive style dimensions, the analytic/heuristic is the better predictor of DSS performance. Actual effect sizes range from -.116 to .610, and total variance is $S_d^2 = .062$, of which 21 percent is sampling error-induced. The credibility interval ranges from -.160 to .708. While these findings imply that analytic decision makers tend to exhibit higher DSS performance, the relatively large crediability interval suggests great variation in this performance.

Twenty-two findings relate dimensions of the Jungian problem-solving styles to DSS performance. The mean effect sizes of these, as seen in Table 4, are smaller than those for the relationship between the analytic/heuristic dimension and DSS performance ($d_u = .204$, $d_a = .245$). Actual effect sizes range from .008 to .716, with 50 percent of the variance due to sampling error. Although the effects of the problem-solving style

Table 4. Analysis of Impact of Individual Differences on DSS Performance

User Factors (Independent Variables)	# of d's	Mean		Variance			%SE	95% Credibility Level		$N_{fs.1}$ *
		d_u	d_a	S_d^2	S_e^2	S_c^2		From	To	
COGNITIVE STYLE	51	.246	.286	.044	.014	.020	.318	-.031	.523	95
Analytic/Heuristic	28	.274	.309	.062	.013	.049	.210	-.160	.708	59
			.334**							
Problem-Solving Style (Jungian Typology)	22	.204	.245	.026	.013	.013	.500	-.019	.429	32
Sensing-Intuition/Thinking-Feeling	6	.255	.279	.062	.021	.041	.339	-.059	.509	7
Extroversion-Introversion (EI)	4	.133	.157	.008	.012	.000	-	-	-	2
Sensing-Intuition (SN)	4	.268	.318	.019	.011	.008	.579	.093	.443	7
Thinking-Feeling (TF)	4	.218	.259	.006	.012	.000	-	-	-	5
Judging-Perception (JP)	4	.190	.225	.013	.021	.019	.387	-.080	.460	4
PERSONALITY	20	.224	.272	.056	.013	.043	.232	-.132	.630	35
	19***	.206	.249	.018	.013	.005	.722	.067	.345	21
Risk-Taking Propensity	8	.279	.364	.028	.011	.017	.393	.023	.535	22
USER-SITUATIONAL VARIABLES	23	.501	.603	.145	.001	.144	.007	-.243	1.245	93
	20***	.429	.514	.083	.010	.073	.121	-.091	.959	-
Training	9	.581	.635	.230	.006	.224	.026	-.347	1.509	49
	6***	.386	.396	.048	.013	.035	.271	.019	.753	18
Experience	10	.346	.434	.097	.009	.088	.093	-.225	.927	25
DSS Experience	5	.388	.493	.096	.008	.088	.083	-.193	.969	20
Work Experience	4	.293	.378	.102	.009	.093	.188	-.305	.891	11
Involvement	4	.616	.849	.089	.001	.088	.011	.035	1.197	30

* ($N_{fs.1}$) - Fail safe effect size of studies in meta-analysis, d_c = .1 (criterion effect size).
** Indicates an attenuation-corrected mean effect size corrected for restriction of range (20).
*** After outlier effect sizes were removed.

dimensions on DSS performance are smaller relative to the analytic/heuristic dimension, they are more consistent. Variation among these effect sizes, evidenced in S_c^2, is about 1/4 that among the effect sizes of the relationship between the analytic/heuristic dimension and DSS performance. For the specific dimensions of problem-solving styles, effect sizes for the sensing-intuition (SN) and judging-perception (JP) dimensions are larger relative to those for the extroversion-introversion (EI) and thinking-feeling (TF) dimensions (Table 4).

Overall, these results suggest that the relationship between cognitive style and DSS performance is small. An effect size of $d_u = .246$ for the relationship between the analytic/heuristic dimension and DSS performance translates to a correlation of .122, which implies that, on average, less than 2 percent of DSS performance can be explained by this dimension. The amount of explained variance is about 1 percent for the problem-solving style category.

Personality

Twenty study findings pertain to the relationships between personality variables and DSS performance. Averaging the actual effect sizes, which range from .000 to 1.642 across studies, and adjusting for measurement error yielded the estimates $d_u = .224$ and $d_a = .272$. Twenty-three percent of the total variation among effect sizes, S_d^2 = .056, is due to sampling error. The credibility interval ranges from -.132 to .630. The effect size (1.642) was suspect given that the mean unbiased effect size was only $d_u = .224$. Therefore, we further examined the study from which this effect size was obtained and concluded it was indeed an outlier. The adjusted results, after removing this finding and recalculating the statistics, are shown in Table 4.

While the few findings available for the personality-DSS performance relationships do not allow a comprehensive search for specific personality variables, there were eight findings relating the personality variable risk-taking propensity to DSS performance. Actual effect sizes for this relationship range from .000 to .473, with averages of $d_u = .279$ and $d_a = .364$. The sampling variation is $S_d^2 = .028$, with nearly 40 percent explained by sampling error, and the credibility interval for d ranges from .023 to .535. These results suggest that the relationship between risk-taking propensity and DSS performance is higher than the relationship between other personality traits and DSS performance.

Demographic Variables

Of eight study findings involving the relationship between basic demographic variables (i.e., age, sex, and education) and DSS performance, no more than three were located for any single demographic variable. Since the results could not be meaningfully integrated given this small number of findings, demographic variables were not considered further in the meta-analysis.

User-Situational Variables

User-situational variables have recently received somewhat more research attention as predictors of DSS performance, (74 percent of 23 findings were reported in the last five years). These variables—training, experience, and involvement—have a relatively larger impact on DSS performance ($d_u = .501$, $d_a = .603$), as shown in Table 4. Effect sizes for this category range from .093 to 1.458. The large variation among effect sizes, indicated by $S_d^2 = .145$ with less than 1 percent explained by sampling error, suggests that this important predictor category warrants closer examination. The credibility interval for d ranges from -.243 to 1.245. Actual effect sizes for training range from .093 to 1.458. Average effect sizes across all nine study findings are $d_u = .581$ and $d_a = .635$. Although reasonably high, these mean effect sizes exhibit great variation. Total variation is S_d^2 = .230 with a credibility interval of -.347 to 1.509. Prompted by this large credibility interval, we examined the distributions of the effect sizes further and found three to be widely dispersed from the remaining six. A systematic comparison of the latter with the studies that produced the three outlying effect sizes found no difference between the sets of studies that could have explained the results. The impact of the three outlying effect sizes on the mean estimates was determined by excluding them and recalculating d_u and d_a. The new averages, $d_u = .386$ and d_a = .396, are shown in Table 4.

The unbiased mean effect size of experience is $d_u = .346$. Observed magnitudes of effect sizes are somewhat lower than the effect range (.080

to .782), but total variance of the effect size is also considerably smaller (S_d^2 = .097). Little of this variation (9.7 percent) is attributable to sampling error. The large credibility interval ranges from -.225 to .927. In order to further examine this relationship, a distinction was made between experience with DSS and more general work experience. Five findings related to DSS experience and performance, and four related to work experience and performance. This analysis suggests that, on the average, DSS experience is more closely related to DSS performance (d_u = .388) than work experience (d_u = .293).

Effect sizes for involvement range from .265 to .942, and the mean effect size of the relationship between involvement and DSS performance is d_u = .616 and d_a = .849, after correcting for measurement error. (The relatively large difference between d_u and d_a is discussed further in the next section.) The observed variation among effect sizes is S_d^2 = .089 with only 1 percent explained by sampling error. Thus, the residual variance, S_c^2, is still relatively large. The credibility interval for *d,* taking into account effects due to sampling error, ranges from .035 to 1.197.

The $N_{fs.1}$ values, displayed in the last column of Table 4, indicate the strength of the relationships between the independent variables examined in the meta-analysis and DSS performance. Here we see that nearly four times (93) as many studies with a zero effect size would be required to lower the observed effect size between user-situational variables and DSS performance to a *d* value of .1. Only about twice as many studies would be needed to produce a negligible effect size of d = .1 for the personality and cognitive style to DSS performance relationships.

Attitudes toward DSS

Results of the effects of the sets of independent variables on attitudes toward DSS are shown in Table 5, which presents a total of 40 findings.

A comparison of the relative magnitudes of effect sizes between Tables 4 and 5 reveals that the effects of cognitive style, personality, and user-situational variables on attitudes toward DSS are similar to the effects of these variables on DSS performance. The relative ordering of the average magnitudes of effect sizes suggests that user-situational variables have the strongest association with attitudes toward DSS. The strength of association between cognitive style variables and DSS attitudes is less than half that of user-situational variables, and personality variables show only small effects.

Impact of study characteristics

As a final step in the analysis of the data, we investigated the potential impact of the study characteristics on the study findings. We conducted this analysis when (1) the total variance after correcting for sampling variation was still large, (2) a chi-square test of homogeneity of effect sizes (Witkin, 1971) indicated significant heterogeneity in the effect sizes, and (3) a minimum of seven effect sizes were available.

For the first relationship of interest, between the analytic/heuristic dimension and DSS performance, the effect was found to be small (d_u = .274 with S_c^2 = .049) (see Table 4). The test of homogeneity yielded a chi-square of χ^2 = 15.120 (d.f. = 27, p < .05), indicating heterogeneity in the effect sizes. Table 6 shows the impact of two methodological characteristics of studies on the observed relationship between the analytic/heuristic dimension and DSS performance. Of 28 findings, 20 used student samples and eight used non-student samples. In terms of average effect size, the results show the analytic/heuristic-DSS performance relationship to be smaller with non-student than with student samples. Findings for the effects of the analytic/heuristic dimension and DSS attitudes were similar (see Table 6). Because there was only one field study, we did not further analyze the effects of type of research design (i.e., laboratory vs. field study).

To study the impact of type of measurement of the analytic/heuristic dimension, we pooled the DSS attitude and DSS performance results,[2] and employed four measurement approaches: (1) the Vasarhelyi (1973) analytic/heuristic reasoning test; (2) the Myers-Briggs F-scale (Myers, 1975); (3) the Barkin's Type I/Type II cognitive style instrument (Barkin and Dickson, 1977); and

[2] Pooling of the DSS attitudes and DSS performance results was done only to investigate the effects of measurement approach of the analytic/heuristic dimensions on the results. All other effect sizes were analyzed separately for DSS performance and DSS attitudes.

Table 5. Analysis of Impact of Individual Differences on User Attitudes Toward DSS

User Factors (Independent Variables)	# of d's	Mean d_u	Mean d_a	Variance S_d^2	Variance S_e^2	Variance S_c^2	%SE	95% Credibility Level From	95% Credibility Level To	$N_{fs.1}$*
COGNITIVE STYLE	18	.348	.441	.075	.014	.061	.184	-.136	.832	62
Analytic/Heuristic	7	.335	.428 .457**	.025	.012	.013	.458	-.111	.554	23
Problem-Solving Style (Jungian Typology)	11	.358	.451	.012	.001	.011	.122	-.152	.564	39
Sensing-Intuition/Thinking-Feeling	3	-	-	-	-	-	-	-	-	-
Extroversion-Introversion (EI)	2	-	-	-	-	-	-	-	-	-
Sensing-Intuition (SN)	2	-	-	-	-	-	-	-	-	-
Thinking-Feeling (TF)	2	-	-	-	-	-	-	-	-	-
Judging-Perception (JP)	2	-	-	-	-	-	-	-	-	-
PERSONALITY	11	.194	.255	.114	.016	.098	.140	-.420	.808	18
Risk-Taking Propensity	5	.150	.205	.009	.020	-.011	-	-	-	6
USER-SITUATIONAL VARIABLES	11 9***	.578 .414	.699 .501	.276 .114	.007 -.011	.269 .403	.025 .051	-.338 -.215	1.736 1.043	53 29
Training	2	-	-	-	-	-	-	-	-	-
Experience	2	-	-	-	-	-	-	-	-	-
Involvement	7 5***	.648 .486	.810 .615	.306 .177	.002 .008	.304 .169	.006 .045	-.433 -.320	1.729 1.292	50 20

* ($N_{fs.1}$) - Fail safe effect size of studies in meta-analysis, d_c = .1 (criterion effect size).
** Indicates an attenuation-corrected mean effect size corrected for restriction of range (20).
*** After outlier effect sizes were removed.

Table 6. Breakdown of Results by Study Characteristics

Independent Variable	# of d's	Mean d_u	Mean d_a
Analytic/Heuristic (Performance)			
Laboratory	27	.295	.324
Field	1	.250	-
Student	20	.335	.359
Non-student	8	.236	.263
Analytic/Heuristic (Attitude)			
Laboratory	5	.336	.499
Field	2	.230	.254
Student	2	.395	.556
Non-student	5	.322	.396

d_u = unbiased mean
d_a = attenuation-corrected mean

(4) the Embedded Figures Test. A cursory examination of the effect sizes reveals large magnitude differences that varied with measurement approach. Using the Vasarhelyi and Myers-Briggs F-scale, we found mean effect sizes of $d_u = .267$ and $d_u = .229$, respectively. When measurements were made with the Type I/Type II and EFT instruments, we found mean effect sizes of $d_u = .359$ and $d_u = .408$, respectively. This suggests that the latter instruments are better at revealing relationships between cognitive style and DSS implementation success as defined in this study.

Large variances in effect sizes were also evident in the relationships between training and experience with performance. The average effect size of the training variable on DSS performance was $d_u = .581$ (see Table 4) with a corrected variance of $S_c^2 = .224$. The test of homogeneity yielded a test statistic of $\chi^2 = 25.835$ with 8 degrees of freedom. This result was statistically significant at the $p < .05$ level, indicating heterogeneity of the effect sizes.

For type of study, the results in Table 7 clearly show that larger training-DSS performance effect sizes tend to be observed in field studies rather than in laboratory experiments. No conclusion could be drawn from the student/non-student samples because student samples were not involved in any of the studies. Large average mean effect sizes were associated with non-student samples, for which there were four findings. The existence of only one experience-DSS performance finding based on a field study and insufficient findings with respect to the relationship of training and experience with DSS attitudes prohibited further analysis in these areas.

Discussion

The three major findings of our meta-analytic study are:

1. **User factors do impact DSS implementation success.** Table 8 summarizes the observed average effect sizes, the magnitudes of which clearly show the impact of user factors on DSS implementation success. Our statistical results, however, show that the impact of user factors on DSS implementation success varies greatly (as evidenced by the corrected sampling error estimates in Tables 4 and 5) and that a large variation exists that remains unexplained.
2. **Some user factors do appear more important than others**. The relative magnitudes of

Table 7. Breakdown of Performance Results by Study Characteristics

Independent Variable	# of d's	Mean d_u	Mean d_a
Training			
Laboratory	4	.451	.451
Field	5	.716	.845
Student	0	-	-
Non-student	9	.581	.635
Experience			
Laboratory	9	.305	.377
Field	1	.782	-
Student	6	.282	.354
Non-student	4	.624	.778

d_u = unbiased mean
d_a = attenuation-corrected mean

Table 8. Effect Sizes Associated With User Factors and DSS Implementation Variables Listed in Descending Order of Magnitude

User Factors	DSS Implementation Performance d_u	DSS Implementation Attitudes d_u
User-Situational Variables		
Involvement	.616	.642
Training	.581	.414
Experience	.346	*
Cognitive Style	.258	.348
Personality	.224	.194

*This effect size was not calculated due to the very small number of studies in this area.

the effect sizes in Table 8 show that larger effect sizes are associated with user-situational variables, smaller effect sizes with cognitive style and personality.

3. **The DSS implementation success rate can be improved by as much as 30 percent**. Perhaps the most interesting question is: What impact does explicit consideration of user factors have on DSS implementation success? As indicated by the binomial effect size display (BESD) estimates in Table 9, the implementation success rate can be increased by 20 to 30 percent through manipulation of user-situational variables and by 10 to 15 percent through consideration of psychological factors.

The specific findings of the meta-analytic study and their implications for future research are discussed below.

User-situational variables

The strength of relationships between user-situational variables and DSS implementation success reinforces the "conventional wisdom" that user involvement and training lead to improved chances of successful system implementation. This is consistent with the views presented in both normative models of organizational change (e.g., the Lewin/Schein Model (Schein, 1972), Kolb/Frohman Model (Kolb and Frohman, 1970)) and the diffusion of innovation model (Cooper and Rosenthal, 1980) of implementation. Organizational change models of implementation highlight the importance of involvement and training (Ginzberg, 1981; Zand and Sorenson, 1975) as the means to create a favorable and acceptable environment for change. This study amplifies our understanding of these popular nostrums in terms of their level of importance.

The strength of the relationship between user involvement and DSS implementation success emphasizes the importance of a priori user involvement (i.e., participation in the planning and design of the DSS) to implementation success. This finding should suggest to DSS designers that they can enhance DSS implementation success by promoting user involvement in the DSS design and development activities.

There is another meta-analytic finding related to the relationship between user involvement and DSS implementation success that we believe has important implications for future research activities in this area. The results in Tables 4 and 5 show relatively large errors of measurement associated with the involvement variable. In this study, we observed, as others have (e.g., Ives and Olson, 1984), that the user involvement construct has been operationalized through a variety of measurement approaches usually involving single-item or multiple-item Likert-type scales. These measurements are most often based on self-reports or user perceptions of their involvement in DSS-related activities gathered after system implementation. Given the strength of the relationships between this variable and DSS implementation success, future research should attempt to develop more valid and reliable measures of user involvement. Furthermore, measurement approaches should differentiate between the various types and degrees of user involvement. *Type* of involvement refers to the form and approach by which affected users participate in DSS-related activities (Ives and Olson, 1984). For example, Zmud and Cox (1979) suggest four types of user involvement: consultation, influence, commitment, and responsibility. *Degree* of involvement refers to the level of influence a user has over the final product (Keen, 1981). (While DSS designers may discard most

Table 9. Best Estimate of the Improvements in DSS Implementation Success as a Function of User Factors

	DSS Implementation	
User Factors	**Performance** d_u	**Attitudes** d_u
User-Situational Variables		
Involvement	.295	.306
Training	.279	.203
Experience	.170	*
Cognitive Style	.128	.171
Personality	.111	.097
Demographic	*	*

* This effect size was not calculated due to the very small number of studies in this area.

Note: All numerical values in this table represent implementation success rate increases. That is, assuming that implementation success can be categorized dichotomously into either success or failure, a value of, say, .279 for the training-DSS performance relationship implies that instituting training programs of the types included in our meta-analysis (versus not instituting such programs during DSS implementation) increases the success rate by 27.9 percent.

or all user input, users can make significant design decisions and/or assess a DSS based on user-defined criteria.) The DSS research community is encouraged to rigorously pursue research studies that focus on configuring the nature of the relationships between form of user involvement and DSS implementation success.

The other two user-situational variables that exhibit effects on DSS performance are training and experience. In our meta-analysis, training was essentially limited to providing the specific computer and software skills needed to interact effectively with a particular DSS (a relatively narrow concept of training). It may be that a more comprehensive approach to training through interaction with other user-situational factors, such as involvement and experience, would exert a stronger influence on DSS implementation success. Training programs might be aimed, for example, at developing users' understanding of *why* a DSS is being introduced and *how* the system will affect them during and after implementation. Such knowledge and understanding may lead to increased user commitment, which may in turn enhance user involvement. Training can thus have a mediating effect on the relationship between involvement and DSS implementation success variables.

Given the magnitude of effect sizes associated with experience and DSS implementation success variables, it is likely that less experienced DSS users can greatly benefit from effective training programs. Training programs can be developed to expand user knowledge of the functional area in which the DSS is being implemented and thus build familiarity and "experience." DSS experience can be similarly enhanced through training programs designed to educate users about general DSS concepts (e.g., problem-solving techniques, modeling and decision-aiding strategies, etc.) as well as about the operation and application of specific DSS tools, hardware, and software. Considering the effect sizes associated with training and DSS performance, we suggest more research projects be conducted in this area. Future research could investigate, for example, the impact of different training approaches (in terms of content and process) on DSS implementation success variables. The large residual variance associated with the effect sizes of training indicates other variables may moderate the relationship between training and DSS performance. Future research should attempt to identify such variables.

DSS experience was also found to be related to DSS performance. (A distinction was made between two types of experience: DSS experience and work-related experience.) Our analysis suggests that performance is more strongly related to DSS experience than to work experience. The large credibility intervals associated with both work and DSS experience suggest the existence of moderators in the relationship between these two variables and DSS performance. Experience, as a construct, was not very well-defined and certainly not consistently operationalized (as evidenced by the large increase in effect size after correcting for measurement errors) in the included in our meta-analysis. Perhaps perience is too broad a construct. If so, future research should make a more refined distinction between different *types* of experience (e.g., EDP experience, general or specific DSS experience, etc.).

Psychological factors

The attention paid to cognitive style variables in the DSS literature notwithstanding, our meta-analytic results indicate that psychological factors have only a small-to-moderate effect on DSS performance and user attitudes. This suggests that perhaps a disproportionate amount of attention has been placed on cognitive style research in the DSS field (e.g., about half of all findings included in the this study pertaining to DSS performance dealt with its relationship to cognitive style).

Our meta-analytic findings provide increased insight into the nature of relationships between dimensions of cognitive style and DSS implementation variables. In the analytic/heuristic dimension, analytic decision makers not only outperform heuristic decision makers, but they also have more positive attitudes toward their DSS. User attitudes are more strongly associated with decision-making and problem-solving dimensions of cognitive style, as represented by the Jungian typology, than with decision-making performance.

In summary, we can draw three general conclusions vis-a-vis the relationships between cognitive style and DSS implementation: (1) the impact of cognitive style on DSS implementation success is relatively small; (2) cognitive style affects user attitudes toward DSS more strongly than it affects DSS performance; and (3) some underlying dimensions of cognitive style are more strongly associated with DSS performance than others. These findings can be explained in the context of the definition and measurement approaches to cognitive style employed in the studies under investigation.

The large variances associated with different representations of cognitive style and DSS implementation success variables highlight the problems associated with defining and measuring the cognitive style construct. The approach used to measure a construct may, according to Locke (1976), be totally incongruous with the definition of the construct. For example, the most logically valid measure of cognitive style would be one that is capable of tracing and measuring decision-making process and its stylistic aspects; however, the MBTI, frequently used in DSS research for this purpose, was not intended to capture a person's decision-making process and thus, as indicated in some research studies (Ginzberg, 1979; Guilford, 1980; Robey, 1983), is not a highly valid measure of cognitive style. These studies have noted that many of the MBTI items do not directly measure decision-making processes and are quite vague in meaning. The small effect size associated with cognitive style (as operationalized by MBTI) and DSS performance can thus be attributed to the inability of this instrument to trace behavior (i.e., performance). Measurement problems associated with the analytic/heuristic dimension of cognitive style and the implications of these problems are discussed in the next section on methodological characteristics.

Methodological characteristics

Several of the variables that moderated the relationship between user factors and DSS performance and attitudes—specifically measurement approaches, research setting, and type of subject—were methodological variables.

Analyses of the impact of operationalization of the analytic/heuristic dimension on the magnitudes of effect sizes observed in the studies showed large variations. This finding amplifies the definitional and measurement problem of cognitive style discussed previously. The EFT instrument, for example, has been shown to be more of an ability test than a representation of cognitive style (Goldstein and Blackman, 1989; Guilford, 1980). Widiger, et al. (1980) found that EFT loaded highly only on an ability factor with other ability tests and failed to converge with "stylistic" tests. Our meta-analysis points to some problematic issues in the measurement of cognitive style in past DSS research. More care must be taken in selecting cognitive style instruments in future DSS research.

The relationships between the analytic/heuristic dimensions of cognitive style and DSS performance were larger for student samples than for student samples. Because all the non-ent subjects participated in laboratory experiments, differences in the mean effect sizes are believed to be artifactual consequences of range restrictions in subject EFT scores (as suggested by the remaining total variances after removing measurement and sampling errors). It may also be that other individual attributes, such as experience, attenuate this relationship. For example, relative to students, more experienced organizational members may adjust or override their measured cognitive style preference in order to meet the demands of the task or DSS. Experienced non-students may also exhibit a smaller range in DSS performance than student subjects; this, in turn, reduces the probability of observing large effect sizes. Our findings concerning the impact of type of subject and experimental setting on the relationship between the analytic/heuristic dimension and user attitudes (Table 6) indicate that non-student samples and field studies generally yield smaller mean effect sizes than student samples and laboratory experiments. There are two explanations for these results. An explanation in terms of internal validity suggests that the high degree of control over extraneous variables found in laboratories would make the higher estimated effect size a better indicator of the true relationship between analytic/heuristic and user attitude variables. An explanation in terms of external validity suggests that college students and laboratory tasks have little in common with real organizational life; hence, field estimates of the effect between analytic/heuristic dimension and user attitudes would be more meaningful. Both explanations undoubtedly have merit. This meta-analysis seems to indicate that the analytic/heuristic dimension has a relatively small effect on user attitudes and that a host of other individual and organizational influences seem to erode this already small effect in field settings.

Another relationship showing a large variance in effect size based on study characteristics is the one between training and DSS performance. Although both the field studies and laboratory experiments investigating the relationship between these two sets of variables involved non-student subjects, large effect sizes were associated mainly with the field studies. This finding may be explained in terms of the realism of the field settings. Subjects in the field, unlike those in a laboratory setting, are usually accountable for future consequences of their behavior and performance. Thus, they may be more motivated to learn, making the DSS training program more effective in terms of user performance. Furthermore, to the extent that tasks and decision support systems involved in laboratory experiments are simpler than those encountered in field studies, the impact of training on performance may be reduced. Also, the longer duration of training programs provided in the field makes them more effective than the shorter training programs in laboratory settings. Finally, training in laboratory studies may be more uniform than in field studies. Overall, large effect sizes associated with the impact of training on performance in field settings reinforce our previous observation that other variables seem to moderate the relationship between these variables. Future research in this area should identify these moderating variables in order to estimate the extent that results in laboratory settings are generalizable to organizational settings.

A study characteristic that tends to moderate the relationship between experience and DSS performance is type of subject (i.e., student, non-student subjects). We found the observed effect sizes in student samples to be substantially smaller than in non-student samples. This finding may be artifactual, attributable to smaller ranges of experience associated with students than with non-students. This finding also further substantiates our earlier recommendations regarding potential future research on the conceptualization, definition, and measurement of different types of experience.

Summary and Conclusions

Our meta-analytic study yields a summary of what has been learned in the area of user factors (individual differences and user-situational variables) and DSS implementation success, from which we were able to derive two specific conclusions:

1. We showed that user factors *do* impact DSS implementation success, that user-situational variables are more important than individual differences, and that manipulating user-situational variables (involvement, training, and experience) can improve the implementation success rate by as much as 30 percent.
2. We estimated the magnitudes of effects that can be expected in research in this area, which may serve, in turn, as benchmarks for future studies.

These findings contribute to future implementation research in several important ways. First, they allow researchers to put into perspective the incremental contribution of additional substantive and empirical studies in this area. For example, research that introduces new concepts and variables and/or any research of the constructive replication variety can be evaluated in terms of relative importance and contribution by calculating effect sizes of the new findings presented in the research study and comparing them to those found in this meta-analyic review. Second, our work suggests the domains (e.g., construct validation research or user involvement) that might profit most from additional research. Third, our findings regarding the impact of methodological characteristics—measurement approaches, research settings (laboratory or field), and subject type (student, nonstudent)—are useful for the design of future research studies of implementation. Finally, most of the previous studies examine the direct relationship between each of the key user factors: involvement, training, decision styles, and DSS implementation success. Our findings suggest interaction effects among these key factors and other variables that seem to moderate their impact on DSS implementation. Thus, future research efforts should be directed toward developing causal models of DSS implementation that weave these key user factors together in a form that makes their interrelationships explicit (Lucas, et al., 1990). We believe a model consisting of an interacting network of relationships among these and other factors will be a more realistic representation of DSS implementation phenomena. Discussion of casual models is beyond the scope of this article. However, a number of researchers have started to use causal models in this area. For example, Tait and Vessey (1989) employ causal modeling to develop a path model of the effect of user involvement on system success. Lucus, et al. (1990) provide a detailed discussion and application of casual modeling to information systems implementation.

We hope our study motivates more research in the suggested areas, resulting in the most important user factors being be included in future implementation research, thereby minimizing the consequences of specification error.

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Appendix A
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Appendix B

Statistics for Meta-Analytic Calculations

1. The weighted, unbiased estimate of effect size d_u, where $d_u = 1/\Sigma w_i[\Sigma w_i d_i]$, $w_i = 2N_i/8 + d_i^2$, and N_i is the sample size of study *i* (Rosenthal, 1984). When no errors of measurement and no restrictions of range exist, d_u is the preferred estimator of the population effect size. Because this estimator weighs each effect size by the sample size of the study on which the finding is based, it emphasizes more reliable findings (i.e., findings based on larger sample sizes) over less reliable ones.

2. The attenuation-corrected mean effect size d_a, where $d_a = d_u/[\sqrt{rel_x}\ \sqrt{rel_y}]$ and rel_x and rel_y denote the reliability estimates of the independent variable and dependent variable, respectively (Hunter, et al., 1982). Thus, d_a corrects for the effects of unreliability in the dependent, as well as in the independent, variable measures. When measurement error is substantial, d_a is a better estimate of the population mean effect size than d_u. For studies in which reliability estimates were not reported, we utilized the reliability estimates reported past validation efforts. For example, if the study report did not provide information on the reliability of the EFT measurement instrument of cognitive style but did use the instrument to study the relationship between the analytic/heuristic dimension of cognitive style and user satisfaction, we utilized the reliability estimate reported by Witkin (1971) to correct the observed effect size by its attenuation due to unreliability. That is, given a previously reported reliability of the EFT instrument of $rel_x = .810$ and a reliability of the user satisfaction instrument of $rel_y = .750$, the observed effect size $d_u = .500$ was corrected for unreliability as: $d_a = .500/[\sqrt{.750} * \sqrt{.810}] = .642$.

3. The estimate S_d^2 of the total population variance δ^2, where $S_d^2 = 1/N[\Sigma N_i(d_i - d_u)^2]$, and $N = \Sigma N_i$. In essence, this is a weighted average of the squared deviations of the observed d_i's and d_u's.

4. The estimate S_e^2 of the variance due to sampling error δ_e^2, where $S_e^2 = 1/N[K(1-d_u^2)^2]$. As an indicator of how much of the total variance is due to sampling error, we calculated the ratio between observed variance and sampling error.

5. The estimate S_c^2 of the corrected variance of the mean effect size δ_e^2, which is the total variance S_d^2 minus the variance due to sampling error S_e^2.

6. The 95% credibility interval for d, estimated by $d_u \pm 1.96 * \sqrt{S_c^2}$. Constructed to facilitate the interpretation of effect sizes, the credibility interval gives an indication of the likely value of the population effect size δ. Larger credibility intervals indicate that the observed effect sizes vary greatly from one study to another, possibly as a result of factors being present in some studies but not in others (e.g., research design characteristics).

7. The fail-safe N (Rosenthal and Rubin, 1982b), $N_{fs.1} = [K(d_u - d_c)]/d_c$, where K is the number of findings in meta-analysis, d_u = weighted unbiased estimates of effect size, and $d_c = .100$ (criterion effect size). The fail-safe N shows the number of additional studies having a zero effect that would be required to lower the observed mean effect size value to a prespecified small value (e.g., $d_c = .1$). This index has been calculated to provide a further indication of the strength of the relationship between the individual difference variable and the DSS implementation success variable. The fail-safe N index was originally motivated by concern about the tendency for studies supporting the null hypothesis (i.e., no significant results) to be buried in file drawers and thus not reported. $N_{fs.1}$ is an index of the strength of a relationship, assuming this reporting bias. We utilized the value of .1 as the criterion effect size, given the lack of a more generally agreed upon criterion in the literature (Orwin, 1983).

8. The binomial effect size display (BESD) (Rosenthal and Rubin, 1982a; Widiger, et al., 1980) estimated by $d/\sqrt{d^2+1}$. BESD displays the change in success rate attributable to a certain treatment or independent variable. According to Rosenthal and Rubin (1982a) the reporting of effect sizes can be made more intuitive and more informative by using the BESD.

   Effect sizes for each investigated relationship were plotted for visual inspection as to normality and to facilitate the identification of outlying effect sizes, i.e., effect sizes that were two or more standard deviations from the mean. Studies containing such outliers were carefully evaluated to identify the source(s) of the large effect size. The mean effect sizes were than recalculated excluding the outlier(s) (Alavi and Joachimsthaler, 1990).