Identifying Risks in Expert System Projects

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Abstract

Many organizations are looking to expert system technology as a means to improve productivity and competitive advantage. As with other technologies, expert systems also have associated risks that managers need to know as they consider new projects. The research reported here is establishing a quantitative approach to assisting managers in identifying these risks. Results of empirical studies and new automated tools are discussed.

1. Introduction

Recent increasing interest in expert system (ES) technology has led to its penetration of a wide variety of corporate and other environments. New kinds of ES applications are started every day. How will this new technology be integrated into the organizations? Studies of organizational reactions to other new information technologies have led some researchers to propose general models to describe the process of organizational assimilation of a new technology. Can any of these models reliably predict the organizational assimilation process (and the potential pitfalls along the way) for ES technology? Consider, for example, the McFarlan-McKenney model [MCFARL83], which describes four phases of absorption of a new technology by an organization:

1. Identification and Initial Investment
2. Experimentation and Learning
3. Control
4. Widespread Technology Transfer

Although the first two phases may seem to clearly apply to ES as well as other new technologies, the applicability of phases 3 and 4 is much less clear. How should ES projects be managed and controlled? Does this technology lend itself to widespread use throughout the organization?

At first glance, ES technology may seem quite different from other technologies in both approach and problem domains. However, we do not yet know how organizations will view this technology and what role(s) they will identify for it. Max Bramer, who has been investigating actual experiences with ES technology in Great Britain, succinctly summarizes the current state of affairs:

"Almost 25 years after the initial pioneering work (on Dendral) at Stanford University, building an ES [application] remains a craft activity performed by a still relatively small band of specialists rather than an exact science or an engineering discipline with a body of practice codified into a methodology." [BRAMER90, p. 2]

Due to the rapid growth of interest in ES, we now have a golden opportunity to study and learn from early attempts to use ES technology. We need to help organizations develop a methodology for identifying the critical success factors that will guide its use of ES technology. [ROCKHA70] We also need to become more aware of the potential pitfalls and risks confronting an ES technology project.

A manager or developer new to ES technology will probably want to know "If I am starting or considering an ES project today, what should I know that will help me? What principles and practices have emerged in the last five years that stop me from having to reinvent the wheel myself? What are the key factors that will determine whether or not I succeed?" [BRAMER90, p. 3] If we are able to observe managers in these situations, we can learn more about what works for organizations implementing ES applications and, therefore, be more effective in
assisting managers who are dealing with ES technology for the first time.

Learning from past experience is important. Often, a new technology has been presented as a "silver bullet" that will do away with a variety of problems. CASE technology was viewed in such a manner in the early and mid-eighties. However, once organizations began using CASE, integration problems and required organizational changes became apparent. Thus, the great initial expectations for CASE did not materialize as quickly as promised. After years of poor sales and vendor shakeouts [BURROWS91, p. 84], CASE is now regaining momentum and expectations are more realistic [STATLAND91, pp. 32-34]. However, lessons learned from the CASE experience are clear [MARIA91, p.18]: if organizations and managers do not understand the role of a particular technology, its potential impact, and the effort required to realize the benefits of that technology, they may be setting themselves up for failure.

Although ES technology has aroused a great deal of interest in organizations, many unanswered questions exist, such as: how can we capture and faithfully represent the expert's knowledge? How should we deal with uncertainty and imprecision? There is often a lack of awareness of potential problems with ES technology and its fit to the organization; consequently, unrealistic expectations may arise, endangering both the ES application and perhaps the organization itself. Thus, ES technology today is in a position similar to that of CASE technology five years ago.

Thus, ES presents managers with a large, unstructured decision problem for which they may not have adequate methods. A manager with little or no past experience with ES may suddenly have to plan, direct, and control an ES development project. This is a situation fraught with risk, especially for managers with neither colleagues nor conceptual tools to which they can turn for assistance.

2. Risk Management

One crucial task for managers is identifying the major risk factors associated with a planned ES application. They may suspect that much of the good news they have heard about ES is either hype or extols certain features that may not be transferred easily to their environment. There is a combination of risks that are common to all projects and unique to ES applications. Therefore, managers must be especially sensitive to them. These risks could include:

1. Developing an application that fails to represent the expert's knowledge
2. Failing to produce a usable system
3. Upsetting people and groups within the organization who may feel threatened by the planned ES application
4. Exposing themselves or the organization to legal liability claims resulting from a malfunction of an ES application

Barry Boehm, who has studied risk analysis in software systems projects for years, remarks that the good managers he has observed were "good risk managers...They were using a concept of risk exposure to guide their priorities and actions. And their projects tended to avoid pitfalls and produce good products." [Boehm91] Avoiding risks altogether is simply not an option for managers with projects involving any complexity. Managers who are beginning projects using ES technology incur an additional layer of risk derived from their unfamiliarity with the characteristics that distinguish expert systems from other information systems, and further, their inability to assess the degree of total risk precisely because they have no frame of reference for any particular risk. Therefore, identifying and controlling these risks is the only way such managers can chart a path for successful ES application development.

3. A Management Tool For ES Project Planning

The Risk Identification Tool for Expert Systems (RITES) is a tool for managers who are planning specific ES applications. Risk identification, an activity that should take place early in project planning, enables the participants to clarify for themselves the factors that contribute to the overall risk associated with the project. RITES represents the authors' views on the major risk factors for ES projects, based on direct experiences developing ES applications, on a review of the literature on this topic, and on empirical data.

3.1 Objective

The authors' tool for risk identification in ES applications addresses the most subjective and qualitative (and possibly the most important) of the steps in risk analysis. We do not suggest that in evaluating a potential ES one should analyze only risk; however, risk analysis is usually a neglected area. Further, risk management should not be equated with risk avoidance. In fact a high
risk exposure project may be considered feasible if the projected payoff warrants it.

3.2 A Risk Identification Tool

Using RITES, managers define the organizational framework and application domain for any ES project. While thorough planning and objective analysis cannot eliminate risks, they can help identify areas needing special attention. The chief objective of RITES is to help managers specify the risk factors relevant to planning and implementing an expert system.

RITES consists of a questionnaire (see Section 3.4 for a description of an automated version of RITES), a scoring scheme, and guidelines for interpreting the scores. The answers are combined to form a graphical representation that depicts the organizational climate for developing an ES. The chief objective of RITES is to help managers identify high-risk factors relevant to a planned expert system. The questionnaire uses "provocative dialogue" to help managers quickly characterize the critical success factors for a specific ES application. The questions are grouped into three sections, which we term dimensions:

I. Organizational Issues
II. Intrinsic Issues Related to Knowledge Domain
III. Personnel and Resources

Managers translate their subjective views into numeric answers using a 1-to-5 scale, where the lower end of the scale always represents lower risk or higher organizational capability, whichever is appropriate. The high end of the scale represents higher risk or lower capability. Each dimension of the questionnaire has several questions. Managers compute their total score and average score for each dimension, and record the unrounded average for each dimension in a Results Table (see Table I, for example) by marking an "X" for that dimension at the appropriate point on the "1-to-5" scale in the table.

3.2.1 Scope of the RITES Tool

I. Organizational Issues Dimension

These questions guide managers through evaluating aspects of their organization that may either assist or hinder the successful development of expert systems. For each aspect, the manager assesses organizational attitudes and modes of operation. Organizational questions address the following, as well as other, issues:

- The tangible or intangible impact of an ES (e.g., improved efficiency or enhanced knowledge about the organization's environment).
- The perception of threats to the organization's internal power structure.
- The expected level of cooperation among managers, experts, and users who are key to the success or failure of an ES application.
- The manager's assessment of the organization's willingness or reluctance to embrace ES technology.

In the example shown in Table I, a manager's assessment resulted in a composite score of 3.2 with respect to organizational issues.

II. The Intrinsic Dimension

These questions prompt the manager to consider the characteristics of the knowledge domain and the availability of experts. Issues include:

- Highly esoteric domains may have less chance of yielding successful ES applications.
- Broad domains may have a complicated knowledge acquisition process, unless the domain can be decomposed into manageable sub-domains.
- Terms and definition of reasoning processes in the knowledge domain may be imprecise. "Fuzziness" will complicate the creation of a verifiable knowledge base by requiring additional expertise in the use of fuzzy logic.
- The degree of competence, cooperation, and communication between the expert(s) and the knowledge engineer will affect the ES development process as well as the outcome.

In the example in Table I, a manager's assessment of intrinsic issues resulted in a composite score of 2.8.

III. Personnel and Resources Dimension

These questions address resources related to the ES

Table I ES Development Tool: Example Responses

<table>
<thead>
<tr>
<th>DIMENSION</th>
<th>SCORE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizational Issues</td>
<td></td>
</tr>
<tr>
<td>Intrinsic</td>
<td></td>
</tr>
<tr>
<td>Personnel/Resources</td>
<td></td>
</tr>
<tr>
<td>Low Risk/High Capability</td>
<td></td>
</tr>
<tr>
<td>High Risk/Low Capability</td>
<td></td>
</tr>
</tbody>
</table>
The questions are in two groups. The first group of questions leads managers to assess the availability, capabilities and experience of the system's development personnel:

- Have personnel ever participated in any aspect of building an ES?
- Does the organization have in-house knowledge engineering capability?

The second group of questions requires managers to rate the level of resources available to the ES project, including:

- Level of funding for ES development (in an organization with no past experience with ES, budgeting may be difficult).
- The expected return on investment.
- The availability of experts for knowledge acquisition (KA). The KA phase of the ES development life cycle is interaction-intensive. Can the organization make the expert(s) available for the KA process?
- The level of end-user involvement and availability of the target group -- if the intended ES user is someone other than the expert(s), these users must be actively involved in the development of the application [Beere87].

Table I shows a composite score of 1.2 with respect to staff capabilities.

3.2.2 Interpreting the Results Table

The Results Table is a graphical profile that the manager can use to visualize a proposed expert system in its combined dimensions. A manager could also use the profile as a basis for "what if?" analyses. For example, in a case where funding and staffing are high-risk factors, what if more funding were available? The manager might then hire someone experienced in ES development, thereby reducing risk in the "Staff Capabilities" dimension. Further, a variety of interpretations are possible for any given result. Here are a few observations that will help in interpreting the Results Table:

- Risk correlates directly with score; the higher the score in any dimension, the greater the risk in that dimension.
- If all dimensions are rated at two or less, the application may be too limited. Nonetheless, such an application may serve as a useful mechanism for demonstrating the viability of this technology to upper management.

- If all dimensions are rated at three or higher, the overall risk is so high that it may be inadvisable to proceed.
- If the organizational and intrinsic dimensions are both rated high (4 or 5), then the Personnel/Resources dimension should be rated low (1 or 2). The inverse of this relation also holds: if the Personnel/Resources dimension is rated high, then the organizational and intrinsic dimensions should be rated low.
- A "well-balanced" result for the three dimensions would be *3-3-1* or *1-1-3*. Either result would indicate that the areas of increased risk are counter-balanced by areas where risk is minimal. Table II shows the *3-3-1* case. This suggests that the proposed ES is complex and there may be significant organizational difficulties to surmount; however, staff capabilities are highly rated and adequate resources are available.

Most organizations should not expect everything to be in place when planning their first ES application. However, using this graphic analysis tool will help managers focus on the important issues and decide how to manage the project, or whether to proceed at all.

3.3 Experiences with RITES: A Pilot Study

In the Fall of 1990, we conducted a pilot study using RITES. We specifically targeted managers who were relatively new to ES technology and who were in the early stages of developing or planning an ES application. We distributed about 30 copies of the RITES tool and received 14 responses. Twelve respondents applied the RITES tool to an actual project.

Summary of Questionnaire Results

To illustrate how the results from RITES can be used, we examine in detail the results for three of the respondents. In Figure 1, we reproduce their results for the three dimensions in the form of the dimension chart used to score the RITES results. Figure 1 also shows the

| Table II Expert System Development Tool: Results Table |
|-----------------|-----------------|
| DIMENSION       | SCORE           |
|                 | low risk/       |
|                 | high capability |
| Organize.       | 1   2   3   4   5 |
| Intrinsic       | 2   3   4   5   6 |
| Personnel/      | 1   2   3   4   5 |
| Resources       |                 |

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average result for all respondents in each dimension.

Respondent 2 -- This person supplied extensive additional notes describing the situation. The organization is developing an "intelligent" system to process travel expense claims for employees of a government agency. The problem is described as not very complex and they have a very capable and cooperative expert working with them. However, the responses to certain questions in the Personnel/Resources dimension suggest very low staff capability in the ES technology area. Given this scenario, the respondent may want to consider bringing in a consultant. This respondent's case indicates that analysis of results cannot be done solely at the dimension level. As the profile in Figure 1 indicates, the composite result in this dimension is not particularly high.

Respondent 4 -- The planned ES application will assist operators monitoring a large dam. This person's chief problems are organizational. Based on the responses in the Organizational dimension, the respondent expects "many significant political barriers to be overcome" and lack of support from at least one group that is important to the ES application development. No other major problems appear in the other dimensions. Although the Personnel/Resources dimension looks good, it does not counterbalance the risk described in the Organizational dimension. The best advice at this time is to pull back until the risk in the Organizational dimension risk can be moderated.

Respondent 8 -- The respondent describes the ES application as one dealing with "tactical Army space technology." The respondents had the highest average score across all dimensions. Further, no low-risk dimension counterbalances the high risk exposure in the Personnel/Resources dimensions. The limited availability of both funds and the expert indicates maximum risk exposure. This project seems to be a disaster in the making. The only positive sign is that the person feels that the broadly defined knowledge domain can easily be subdivided. Such division of the domain, however, requires cooperation, which in this environment, could introduce another high-risk element. This may require restricting the scope of the project.

3.4 An Automated Tool

In 1991, the RITES questionnaire is being expanded and automated. Our goal is to provide a tool that can be used on a micro-computer, offer built-in analyses of user responses, provide "what-if" scenarios based on the user's view of the ES application, and provide "advice" about certain risk areas.

Figures 2 and 3 depict user screen sequences for a question concerning Organizational Effectiveness. At the beginning of each question, users are prompted with background information that is useful for interpreting the
question (Figure 2). The background information helps respondents to understand their organization within the framework of the issue(s) being evaluated. The evaluation for each question within each dimension is listed in increasing order of risk (Figure 3). Users select their response by locating the cursor along a scale (from 1 to 5) that best represents their risk position.

In addition to answering the question, users can enter textual comments, request help, scroll forward and backward through screens, depict where they are within the series of questions, elect not to respond to a question, create more than one response to a question when they have alternatives available within their environment, interrupt their use of the questionnaire (saving partially answered questionnaire) to return at a later time, and view scoring for individual questions and composite dimensions. Automated RITES also provides a risk analysis that identifies particularly risk-laden combinations of conditions in the respondent's organization or ES application and provides "advice" about ways to reduce risk in certain areas. Since RITES itself may be an ES candidate, we are experimenting with an ES implementation of the RITES tool.

3.5 Goals and Conclusions

Our 1990 pilot study elicited responses to both the RITES questions and the questionnaire itself. Most of the respondents gave us comments. The comments covered wording of questions and of the text corresponding to each of the ratings for a question; suggestions for changes in the order of the questions; and suggestions for new questions.

In general, the results indicated that people seem relatively well prepared for ES development, but this may be misleading. If the respondents were well into the stage of design or development, they may have been reluctant to evaluate their application as "high risk." We did find a large number of respondents who expected difficulty in getting adequate time with the expert during system development. Since no one is more central to ES development than the expert, this finding is alarming. We will refine our questions in the next version of RITES to allow us to probe this issue in more detail. Our first study using a revised version of RITES is now underway.

Because this was a pilot study, we intentionally avoid making sweeping conclusions about ES application risks in this article. The information and feedback we have received from the pilot study suggests that some organizations are launching ES projects with either major obstacles or a lack of understanding. We will also examine these issues in future studies.

We plan to select a group of participants for a broader RITES study to follow their progress in developing (or choosing not to develop) an ES application over the next several years. This will enable us to study the factors that actually proved, over time, to be critical to the success or failure of ES application projects.

Expert Systems technology has arrived, and many ongoing investigations are trying to improve the quality of knowledge and expertise embedded in ES's [Murdoch90]. Even while this research continues, however, many organizations are moving ahead and actively planning ES applications. We know from 30 years of collective experience in Information Systems about the many potential pitfalls in introducing a new technology. Risk-driven approaches seem well suited to such situations. But the first problem for managers, especially those new to ES, is to identify the areas of risk exposure; tools such as RITES will help.

RITES is available from the authors either as a printed questionnaire or in its automated form to those who may be interested in using it or participating in an ongoing study. If you wish to obtain RITES, contact:

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References


Statland, Norman, 1989, "Payoffs Down the Pike: A CASE Study", Datamation, April, pp. 32-34.

