Use of GDSS in technology selection: Experiences and findings

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Abstract

Companies are faced with a difficult and complex choice problem when evaluating and selecting technologies. The increasing number of technological alternatives and the shortening response time ever tighten competition, and the problem of selecting appropriate technology is more complicated than before. Group Decision Support Systems (GDSS) offer many potential benefits for promoting technology selection processes. The purpose of this study is to clarify the real advantages and problems of GDSS in supporting technology selection in companies. The advantages and restrictions are discussed on the basis of several selection applications carried out during the years 1994-2000.

1. Introduction

This study focuses on the problems of comparing several competing technologies for the purpose of evaluating or prioritizing them in industrial companies. The difficulty of technology evaluation and selection grows when the number of alternatives and the number of criteria increase [4]. The target of the company can be on the wrong technology or maybe too many technologies. Technology selection and prioritization are very important for effective technology management. The right technologies could create remarkable competitive advantage [5, 14, 21]. Group decision support systems (GDSS) offer good possibilities to improve the performance of management decision making in technology selection.

Many different methods and approaches have been developed to support the selection of technology or technology projects (see e.g. Arbel et al [1], Currie [7], Fahrni and Spätig [10]). Utilization of these devices is not common and regular in many companies. The lack of a common and consistently applied selection approach, or the difficulty to choose the appropriate selection method for the company's intentions can be a problem in many companies. Generally companies use only conventional financial methods to support technology selection decisions. These methods are a good basis for decisions, but do not succeed at predicting the competence potential of the technology well. They often overestimate short-term advantages rather than the company's long-term strategic benefits. In addition, many of the earlier developed methods do not give enough support to group work and communication. A wide and comprehensive group of experts should participate in the company's technology selection process. This group should include all functions across the company and representatives of the different levels in the company, which the technology may affect. People from different departments with different knowledge background must have a possibility to work effectively as a group for the selection of new technologies that will benefit the entire company most.

In this paper a general process for the evaluation and selection of technologies in groups is presented. The applicability and adaptability of the process are studied from the perspective of different technology types: product, production and information technology. A GDSS offers many potential benefits for promoting technology selection processes. The advantages and restrictions of GDSS in supporting the technology selection process have been studied through several organized sessions for industrial companies carried out at Lappeenranta University of Technology (LUT) during 1994-2000.

2. Technology selection

Industrial companies use many technologies in their operations. According to Betz [3] some of these technologies are extremely important to the business and can be called core technologies for the company. The other technologies that the company uses will also be necessary, but may not be unique especially in the industry where the company operates. This study focuses on the strategic evaluation and selection of the core technologies, which are the most vital part of a company's competitiveness and survival in long term.

Many studies have been conducted about the selection of projects or products (see e.g. Stewart [22], Bard et al [2]). According to Melachrinoudis and Rice [13], the evaluation of technologies to be selected is a different task from the evaluation of products (or projects). First, because different evaluation criteria have to be used and,

second, since technologies are usually very much broader in scope than project proposals, their evaluation is based on much more uncertain information. In addition, the technologies selected draw new R&D directions for the company which will affect the content of future product proposals.

The selection of technologies is a management process of making a choice between a number of distinct technology alternatives. It suggests the gathering of information from various sources about the alternatives, and the evaluation of the alternatives against each other or a set of criteria. Melachrinoudis and Rice [13] have emphasized the fact that the task of comparing many competing technologies for the purpose of evaluating them becomes very complex due to the many subjective, partially contradictory and complex criteria involved, and the lack of information or uncertainty on the potential contributions of the technologies toward the criteria or objectives. This makes technology selection one of the most challenging decision making areas the management of a company encounters. One challenge that Porter et al. [20] state rises from the effects of technology that may occur after a long period of time.

In order to understand the requirements and criteria for the specific technology selection, technologies must be categorized in some way. Steele [21] and Betz [3], among others, have roughly classified technologies into three dimensions:

1. Product/service technologies
   = "product technologies"
2. Manufacturing/service-delivery technologies
   = "production technologies"
3. Information/operations technologies for management control
   = "information technologies"

This classification helps in understanding the technology specific requirements for the selection process and the supporting tools used in the process. When carrying out a real process, identification of company specific criteria is needed. Usually this involves the consideration of a variety of factors, such as business and technology strategy, availability of resources and competitive position and markets. Drawing from the appropriate literature, we have identified common and most utilized criteria associated with selection of different technologies and use these criteria to set requirements for the selection process and the tools to be utilized.

Farrukh et al [11] have defined a number of general criteria which should be taken into consideration in the selection of technologies for R&D programs (see table 1). Cooper [6] has identified four main approaches to project evaluation, which can be adapted to technology selection as well. He emphasizes that the problem is usually about resource allocation among a number of projects or technologies and there is no one and the best way to solve the problem. Cooper's four approaches include benefit measurement, economic, portfolio selection and market research models. Yap and Souder [25] have emphasized that several characteristics of technologies should be taken into account in any technology selection model. These include the uncertainties of commercial and technical success, the funding history of the technologies, the resource requirements to develop technologies, the degree to which the technologies contribute to established missions, and the current life-cycle stage of the technologies. Besides, there can be many relationships between different technologies that must be taken into consideration. The technology to be selected must match the present technologies and systems of the company.

Table 1. Technology selection [11] p. 47

Cost versus benefit	Market conditions
Bounds of technology	Deferred projects – increases risk
Radical versus incremental	Commercial risk
Make versus buy versus collaborate	Time-scale pressure
Time to maturity	Key skills
Urgency	Trickle funding
Performance related parameters	Generic technology
Flexibility	Risk assessment

The selection factors that Fahrni and Spätig [10] have defined include concentration on the most critical problem, the degree of quantification of relevant factors, the degree of interdependencies between projects (technologies), consideration of single or multiple objectives and the degree of risk. According to Arbel and Shapira [1] there is a need for a systematic analysis of factors involved in the selection, considering the criteria and parameters leading to the evaluation and selection of an optimal choice. Their selection model focuses on two major groups of issues: benefit and cost. Piippo and Tuominen [17] have emphasized the match of alternatives to the capabilities and strategies of companies and risks as major factors in selection, in addition to benefits and costs. Very few studies have been carried out concerning technology evaluation in groups. The one that we have found, Noori [15] has presented the conceptual design of a GDSS to automate the new technology adoption decision process. He has divided the decision model into three phases: decision criteria analysis, alternative analysis and performance evaluation. One main difference to this in our

approach is in the support of a face-to-face decision room meeting, where communication between the participants and consensus achieving have an important role. In addition, our approach contains decision support in a broad scope starting from idea generation and concluding in a list of tasks and responsibilities.

The criteria involved in selection decisions can vary quite a lot depending on the characteristics of the technology and the organization. Regardless of the criteria used, the selection process must meet some basic requirements. Platts [19] has presented some common characteristics of successful selection methodologies (see table 2). These success factors were considered carefully when developing and carrying out the GDSS supported technology selection processes at LUT.

Table 2. Characteristics of successful methodologies [19].

PROCEDURE • Well defined stages • Simple tools and techniques • Producing written records	PROJECT MANAGING • Adequate resourcing • Agreed timescales
PARTICIPATION • Individual and group • Workshop style meetings • Decision making leading to action	POINT OF ENTRY • Clearly defined expectations • Ways to establish understanding, agreement and commitment

Information from different experts working in different departments and positions is needed to select the best technology for the company. All persons influenced by the selected technology should have a possibility to participate in the definition and evaluation of criteria. When several people are involved in the decision making process, they can assist each other in sharpening their evaluations and also divide the task to provide the evaluations in their area of experience, thus complementing each other [15]. For this reason it is important to support communication and the achieving of consensus.

Evaluation of different effects of technology in a group sets requirements both for the communication support and the assessment tool. Common goals and language among participants are very important for consensus and commitment to decisions. The technology selection process is usually executed by a group of specialists and managers. An effective way to promote the selection process is to increase analytic communication between the participants. In this paper we study how the possibilities of GDSS can respond to the requirement of technology selection and benefit technology evaluation and selection in general.

3. Group Decision Support System and GDSS-laboratory at LUT

A group decision support system (GDSS) aids a group to cooperate and work effectively together to reach its goals. The purpose of a GDSS is to support and develop the group decision making process. A GDSS, according to DeSanctis and Gallupe [9], is an interactive computer-based system that facilitates the solving of unstructured problems by a group of decision-makers. GDSS supports group decision making by eliminating the barriers of communication, by offering different tools for the group and by leading the use of time and handling of items systematically. The components of a GDSS include hardware, software, people and procedures.

GDSS can affect group productivity and effectiveness in several ways. On the basis of a comprehensive GDSS review, the following features are valuable in technology selection decisions [8, 12, 23]:

- GDSS enables parallel communication between group members. Every group member can contribute simultaneously and in parallel.
- GDSS offers an equal and anonymous opportunity to contribute ideas and opinions.
- GDSS eliminates too big domination of participants in meetings.
- GDSS makes it is possible to find out rapidly the agreed and disagreed opinions of group members.
- GDSS helps to manage the schedule and agenda of the meeting.
- GDSS provides effective automatic electronic documentation capabilities.

The Department of Industrial Engineering and Management at LUT has a GDSS-laboratory for the research of group decision support processes and systems. The laboratory is used in teaching and research, and in cooperation with companies for group decision and group work. The purpose of the research done in the GDSS-laboratory is to develop planning and evaluation processes for demanding management tasks in industrial enterprises. The main topic of research is when and how computer aided GDSS is worth using and when not.

The planning of the laboratory was started in 1990 and it was completed in 1994. It is planned to support 10-person meetings and there is a possibility for 1000-person remote use. The laboratory consists of computers, standard and specialized software and group decision support processes planned by researchers at LUT.

One of the main software programs to support the whole group decision process is GroupSystems (GS). GS has been developed at the University of Arizona and Ventana Corporation. GS is a suite of team-based decision software tools that aids and supports a group in decision making. GS can support all phases in the decision making process from problem definition to final selection. It includes half a dozen different analyzing, categorizing, idea generating and evaluating tools. Data transfer between the different tools is simple [24].

4. Evaluation and selection process for technologies

The goal in developing the process at LUT was to determine a compact amount of phases for a systematic selection process (see figure 1). The process aims to promote co-operation between different functions and departments to evaluate and select alternative technologies. Many sequential steps are needed in the selection process. We have determined a five-phase process for the evaluation and selection of technologies. It is based on both the requirements of the technology selection and the possibilities of the GDSS described above.

Before a technology selection meeting can be successfully carried out, an accurate timetable and company specific aspects have to be determined. This is the preparation phase, where the researchers meet the company's representatives, plan a detailed agenda for the session and select the experts to participate in the session.

Preparation phase: PLANNING AND REVIEW OF THE EVALUATION PROCESS	• Preparation meetings with the company • Selection of participants (extensive group of experts) • Purpose, goals and schedule
Phase 1: MAPPING AND CLASSIFICATION OF CRITERIA Categorizer tool	• Knowledge based requirements • Evaluation criteria
Phase 2: DETERMINATION OF THE IMPORTANCE OF CRITERIA Vote tool	• Evaluations on importance of criteria • Classification of criteria
Phase 3: ASSESSMENT OF ALTERNATIVE TECHNOLOGIES Alternative Analysis tool	• Technology alternatives' capabilities to fulfill criteria
Phase 4: ANALYSIS OF RESULTS AND SELECTION OF TECHNOLOGIES Examination of voting results	• Number of surpassed and failed important criteria of different alternatives • Total weighted points • The best technology for company
Phase 5: ANALYSIS OF IMPACTS OF SELECTED TECHNOLOGY Topic Commenter tool	• Impact of the selected technology on different operations and strategic business units • How to avoid the negative impacts of the failed criteria?
Extra phase: EVALUATION OF SELECTION PROCESS Survey tool	• Participants opinions about selection process • Development needs for the process

Figure 1. Main phases and aspects of the technology selection process.

The agenda includes the actual phases and the tools to be used in the phases, as well as breaks and lunch activities. The first main phase of the process focuses on the mapping and classification of the criteria needed in the evaluation. The purpose of the first phase is to clarify all the appropriate criteria and then to categorize them into a

rational classification. When generating a lot of ideas about the criteria to be considered, the GDSS helps by shared displays and a public screen. All participants can see the others' ideas and comment on those ideas concurrently, which speeds up the mapping and enhances the reliability of the classification. All the necessary facts about the criteria can be perceived.

The second phase, determination of the importance of the criteria is needed to get an adjusted impact of a single criterion to the technologies. Different technologies could have remarkably different effects on the company's business, thus the criterion weight for the assessment and evaluation of alternative technologies has to be concluded.

The third phase focuses on the assessment of alternative technologies. In this phase the participants fill out a matrix where thus compare technology alternatives against criteria by giving votes about the technology's ability to fulfil a criterion. The Alternative Analysis tool automatically calculates the weighted results that are the basis for discussion and final assessment of technologies. The tool helps to clarify the importance of the criteria under every category rapidly. In this phase the participants should discuss the disagreeing opinions on the basis of a matrix of voting results. Discussion is important for having consensus among the participants, and to check if some important aspect or fact has not been noticed during the voting. The task in the fourth phase of the process is to analyze the results of the assessment and then finally select the best possible technology for the company.

The purpose of the fifth phase is to analyze the impacts of the selected technology on the different operations and departments of the company. The technology has to match the objectives determined in the preparation phase. The potential of the selected technology to strengthen the existent business as well as the possibilities to avoid troublesome drawbacks are analyzed in this phase. The working mode is discussion and electronic commenting when all opinions are automatically documented.

Finally, as an extra phase of the selection process, but important for research, we have asked the participants about the usefulness of the approach and its results, the fluency of the process and the effectiveness of the session with the help of an electronic survey. The electronic survey clarifies how well the evaluation process has fulfilled the expectations and served the goals, and committed the participants to the results of the selection process. Also information about the benefits, drawbacks and development needs are collected.

5. Discussion

In this study a general process for technology evaluation and selection was presented. The process was developed taking carefully into account the requirements of technology selection, the possibilities of GDSS and the characteristics of successful selection methodologies presented in table 2 above. The possibilities, advantages and limitations of GDSS to support technology selection in companies were analyzed by carrying out the process in Finnish companies. The systematic selection process reveals areas where there is shortage of information in the present knowledge. Alternation between computer supported and traditional discussion seems to be very fertile in some situations and makes the meetings more effective. First mapping and then discussing of the technology selection criteria create a common language to the participants for discussing technology alternatives and prioritizing them. The identification of and communication on the technological gaps to be filled in the organization are easier with a systematic process.

GDSS proved to be an effective and rapid way of evaluating the different technologies. According to the participants, GDSS helped them to concentrate on the facts and deal with the questions in a more neutral way. The participants considered the ability to work systematically, rapidly and anonymously, as well as the ability to give comments easily, the best properties of the GDSS. GDSS makes it easier to communicate with participants from different organizational levels, and across functional barriers.

An extensive group of managers and experts, capable of performing fluent and effective co-operation, are needed for successful technology selection processes. GDSS offers significant possibilities to support group work and to make group decisions more effectively, when applied in the right areas in the right way. GDSS offered many benefits for the technology selection process in our empirical tests. First the experts could simultaneously define different requirements for the technology and focus on their own expertise areas, while they were still able to see the requirements stated by other experts in different areas. When evaluating the technologies, the agreeing and disagreeing opinions could be clarified rapidly, which made it easier to search for facts for evaluations. Anonymous entry possibilities gave democratic, impartial participation opportunities for all the participants. Finally, the pre-planned evaluation process helped to manage the schedule and direct the focus of discussions in the different phases of the evaluation process. The observed advantages of GDSS for the technology selection are very similar to its general possibilities. We have carried out several other similar sessions in the GDSS-laboratory at LUT (see e.g Piippo et al [18], Ojanen et al [16]). The findings from the other developed evaluation processes and the executed sessions support the above results. GDSS makes it possible to support many different kinds of evaluation processes. The general process suits well for this kind of applications and it can be easily modified for

technology selection processes with similar basis in different kinds of industrial companies.

The presented general process shows what a demanding and complex task the selection of technology is. The evaluation process helps to clarify the impacts of technology to the organization in a systematic way. The increased understanding of the criteria of technology selection among participants can be used to help in the setting of priorities between different technologies, products and markets, while also focusing attention on the long-acting relationship between technology selection and the business of the company. The importance of technology selection can be more reliably demonstrated and more easily communicated to all the persons participating in the selection process.

The personnel may see things differently from the management, unless they are involved in the selection and discussion of technologies. The evaluation and selection process should include many key persons from the company's different departments. This ensures the fact that different opinions, ideas and suggestions are obtained and that people are more willing to commit themselves to the objectives. Strategic technology selection can then be seen as an internal agreement on the company's objectives and the use of its resources. Generally it can be concluded that the developed GDSS-supported process provides a fairly good approach for communication about technology selection in organizations.

As a reverse side of the generation of a lot of ideas fast, classification of a list of items into categories is a time consuming and sometimes even confusing task when there are lots of items in the list. A dynamic voting tool where the proper category of an idea is determined by real time voting is needed to promote the Categorizer tool of the GroupSystems. For example it should be made possible to determine a kind of consensus index in advance. When a sufficient amount of cast votes are addressed to a certain category, the idea is carried automatically to that category. A boundary for the consensus index could be for example somewhere between 50 to 80 %, depending on the content of the meeting and the consensus needed.

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