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A DECISION SUPPORT SYSTEM TO SUPPORT SOFTWARE QUALITY THROUGH THE SELECTION OF CASE TOOLS[1]

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Abstract

The use of Computer Aided Software Engineering (CASE) tools has had a major impact on the productivity and quality of products (software) by providing automated support for tasks involving analysis, design, error checking, consistency validation, documentation, reliable code generation through tests, and integration.

A wide variety of such tools is available on the market and these vary in their ability to provide support for the different stages or activities of the life cycle, and in the degree of integration and cost.

The purpose of this article is to present the development of a Decision Support System to assist in selecting CASE tools. The system incorporates the integration of two technology-oriented decision models and the organization of each of them. These models cover a series of metrics on which the decision-making process will be based. These two models were developed and adapted to meet Venezuelan organizations' need for this type of technology. This need is the reflection of a complex process in which there are different underlying criteria.

Keywords: Decision support systems, CASE tools, decision model, software quality

Introduction

For some years now the market has been offering a wide range of automated tools to support the software development process and the Computer Aided Software Engineering (CASE) concept has become a commonly used term in Software Engineering (Sommerville 1998).

Diverse authors through different perspectives have modeled the CASE tool adoption process, some of them approach mainly the technological aspects of the tools, other researches are related with the organizational point of view, others combine both. This induces to think that the correct solution is complex. Some previous research are summarized through the Table 1.

According to Bruckhaus et al. (1996) the impact of a tool depends not only on the properties that possesses, but also the characteristics of IS development project and the organization that adopts it. This shows that the process of selecting, acquiring and implementing a CASE tool in an organization is far from easy. This is due to various factors liable to affect the adoption of a CASE tool and, in some cases, to the complexity because of the number amount of functions they may offer. "It is not feasible to design a single set of criteria that can be used to evaluate all software tools and environments " (Kavi and Nahouraii 1996).

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Table 1. CASE Tools Research

Orlikowski (1993)	Change nature and center associated with the CASE tools.
Premkumar and Potter, (1995)	Research model of technological and organizational variables, for adopting CASE tools.
Iivari (1996)	Conceptual Model of CASE tools Adoption.
Chau (1996)	Research Model of CASE tools Adoption.
Yang (1999)	Research Model for the success of the CASE tools Adoption.
Mendoza et al. (1999)	Model of organizational indicators.
Rojas et al. (2000)	Model of technological indicators for selecting CASE tools.

The selection of CASE tools is a very important strategic process for an organization that develops IS given the fact that their timely and accurate selection has a very competitive value. According to Kavi and Nahouraii (1996) “software quality can be greatly improved by selecting a correct development tool to assist in each phase of the development process, from requirements analysis to final testing an d integration”.

CASE Tools

The goal sought by a company when acquiring CASE tools is to make systems development more productive. According to Kendall and Kendall (1997), the three main approaches followed by the analyst when adopting integrated environment technologies are: to increase productivity, to employ greater efficacy when communicating with users, and to integrate the work undertaken on the system from the beginning to the end of the development cycle. All this results in a better quality end product due to an improved development process.

The problem today is that CASE tools are very expensive. Kavi and Nahouraii cited by Mendoza et al. (2000) say that not only the purchase cost of the tool must be taken into account, but also “acquisition expenditure, training project members to use the tool, converting current designs and data from one format to another, re-entering some data form existing designs into new designs, and writing ad hoc scripts and filters for conversions between different tools or formats. Thus, a project manager is understandably reluctant to consider a new tool or tool suite unless its benefits can be evaluated and presented in convincing manner”.

One of the main objectives of a company when it adopts a CASE tool is to improve the development process of Information Systems significantly. However, this decision is affected by numerous factors and the tool’s potential benefits for the company must somehow be measured, since “selecting an innapropiate tool, on the other hand, can actually hinder software development” (Kavi and Nahouraii 1996). It must therefore be noted that the purchase of a CASE tool not only affects software development within a company, but also involves a process of organizational change (Mendoza et al. 2000). This organizational aspect is not easy to measure in numeric or quantitative terms, since the factors or variables to be taken into account have to be specified. Recent studies have set up organizational and technological metrics that must be taken into account to set a measurement and facilitate the CASE tools selection process. According to the values obtained when quantifying the results, hopefully the most suitable tool(s) to suit the company's characteristics and needs would be obtained

Models for Selecting a Case Tool

A CASE tool must be adopted following careful selection, since it will have a major impact on the organization. Thus both technical and organizational aspects must be taken into account. The indicators proposed by each selected model are based in previous studies, that were taken to the practice in organiztions of software development in Venezuela.

- **The Technological Model:** Rojas et al. (2000) propose a set of technological metrics, divided into *internal and external* ones. The *internal* metrics (that refer to the tool’s internal architecture and structure) are sub-divided into two criteria: scope (what the tool covers) and *design* (what the tool is like); while the *external* ones (factors that are complementary to the tools' environment) are sub-divided into *support and soundness* of the developing company (See Figure 1).

	Technological Factors for Evaluating CASE tools			
Categories	**Internal**		**External**	
Criteria	**Scope**	**Design**	**Support**	**Soundness**
Sub-criteria	*Life Cycle Phases*	*Easy to use*	*Technical Support*	*Developer´s Prestige*
	Components	*Functionality*	*Training*	*Costs*
	Number of users	*Learning Curve*	*Support Material*	
	Project Control	*Online Help*		
	Software Platform	*Type of integration required*		
	Database Manager			

Figure 1. Semantic Tree of Technological Criteria
(Source: Adapted from Rojas et al. 2000)

The metrics associated with these sub-criteria enable an in-depth analysis of each tool to be made and the full extent of their strengths and weaknesses to be known. This leads to a clear understanding of the technical capacities of the CASE tools studied. The algorithm supporting this decision model consists of six finite and sequential steps, shown in Figure 2, through which the set of CASE tools that meet the organization's requirements is obtained.

Step 1. Calculation the values of the indicators by each CASE tool: applying indicators to obtain data.
Step 2. Classification of the results by type of indicator: due the indicators are in different scales.
Step 3. Equivalence of each type: transforming to the same scale.
Step 4. Analysis of compliance by rate: analyzing the behavior of the rate type indicators.
Step 5. Level of coverage of the rates: analysis for each indicator, was it total or partially covered?
Step 6. Total of results by each tool

Figure 2. Algorithm Supporting Decision Model (Technological Perspective)
(Source: Rojas et al. 2000)

This model provides a quantitative way of comparing different CASE tools. However, it does not take account of the environment in which the application will function; in other words, it does not measure the degree of acceptance by users or their possible relationship with the tools. A model is shown further on that deals with the adoption of CASE tools from this perspective.

- **The organizational model:** In this model, Mendoza et al. (2000) (Rojas et al. 1999) propose the exploration of the organization as the environment for which a CASE tool is adopted, thereby measuring the degree to which the company is prepared to undertake such a change, taking into account the possible consequences. In order to do so it proposes a set of organizational metrics, split into *internal and external* ones, the *external* ones (which encompass factors whose origin is not exclusively the organization developing IS) are sub-divided into two criteria: *image* (image reflected by an IS developing unit in its environment) and *corporation* (vision and position of an organization on the development of IS and on the acquisition and management of technological innovations); while the *internal* ones (which encompass factors that are within the scope of the organization developing IS) are sub-divided into *management* (development of management processes within an IS developing unit) and o*peration* (development of the operational processes within the IS developing organization to undertake projects). This is shown in Figure 3.

  This model shows whether a company is ready to adopt a CASE tool. It is not a specific study of the tool that should be selected, which is not a limitation of the model, since the choice of a specific tool is extremely important for the organization. The algorithm supporting this decision model consists of a six step sequence, illustrated in Figure 4.

  The objective is to determine how an organization behaves towards the adoption of CASE tools, showing a quantitative result that enables the organization to be classified in terms of its capacity to adopt this technology, and also makes it possible to compare different organizations or sectors.

	Organizational Factors for Evaluating CASE Tools			
Categories	**Internal**		**External**	
Criteria	**Management**	**Operation**	**Image**	**Corporation**
Sub-criteria	*Management Support*	*Participation of IS analysts in decision-making within the unit*	*Impact of IS on the organization*	*Support by Top Management*
	Implementation process	*Compatibility with development methodology*	*Position of IS developing unit in the organizational structure*	*Resistance to technological innovation*
	Software and hardware update process	*Analysts' capacities and skills*	*Organization's dependence on IS for its productivity*	*Applications backlongs*
	Training plan			*Strategic vision of IS*
	Organizational structure			
	Project management			

Figure 3. Semantic Tree of Organizational Criteria
(Source: Adapted by Rojas et al. 1999)

There is clearly a need therefore to integrate these two models into one decision model that would enable the weaknesses of each of them to be overcome and their strengths combined. This integrated model was the core of a DSS that made it possible to lend efficacious support to the improvement of the software development processes through the selection of the best tool.

Step1. Classification of sectors: in Banking, Consultancy, Government, IS Development or Service sector.
Step 2. Preparation of the technical card: drafting the "technical file" to characterize the participating companies in the sector, based on the information supplied by the persons interviewed
Step 3. Stadistical data: Preparation of frequency distributions, central trend measurements and variability measurements.
Step 4. First analysis level: analyzing the measurements obtained from each indicator-measuring variable for each type of person interviewed and grouping per sectors.
Step 5. Standardization of the values obtained for each variable measured by the indicators.
Step 6. Second analysis level: analyzing the scores obtained by the indicators for each production sector and, finally obtaining a comparative analysis among the sectors.

Figure 4. Algorithm Supporting Decision Model (Organizational Perspective)
(Source: Adapted from Mendoza et al. 2000)

Implementation of a Decision Support System for Selecting CASE Tools

Decision Support Systems (DSS) are a type of Management Information System that enables the decision-making process to be supported from beginning to end. The strength of these systems lies in their ability to support decision-making processes requring the automated application of human criterion (Zwass 1992).

The decision support system developed in this research took three components into account (Turban and Aronson 1998): a *data base, a graphical interface and a decision model* developed by the research group of the Laboratory Information Systems Investigation (LISI) on the basis of the models presented. It is based both on the organizational metrics and on the technological metrics.

Decision Model

Although the model's main objective is to make an overall evaluation of the tools and the organization, it can be partially executed to evaluate the technological aspect.

If the organization only wants to make a technological analysis of the CASE tools, the model allows the critical requirements of it to be evaluated through a set of 5 rates that represent the hardware and software platform needed by the organization. This evaluation can generate an initial classification of tools. At this point the organization can decide whether or not to proceed further.

If it does go on, the following steps will enable the organization to make a fuller technological evaluation of the tools by applying all the appropriate metrics and generating a new output from which the organization will select those that will take part in the application of the integrated decision model.

Now it is time to check for existing updated data on the organization. If this model has been used previously for this organization, its data will be stored; if on the other hand this information is not available (if the model is being used for the first time) the corresponding sub-characteristics are evaluated and, based on the values obtained, the weight for the organizational characteristics is calculated. This weight will depend directly on the values obtained in the application of the metrics.

The following step is intended to take all the weights of the characteristics to the same scale in order to apply the function that relates the weights of each organizational characteristic to the corresponding technological sub-characteristics. This results in a value that enables the tools evaluated to be arranged or classified from both points of view: technological and organizational.

The integrated model used is shown in Figure 5:

In this way each model's limitations can be overcome separately and the main objective of the research achieved; i.e. to provide the organizations with support in the CASE tools selection process according to their characteristics and capacities.

Basic functions of the DSS

In order to support the tasks involved in the application of this model, DSS development focused on responding to a group of functional requirements. Consequently, the system's basic functions consist of:

- LISI1 - insert, modify, delete and consult general data on the CASE tools.
- LISI2 - insert, modify, delete and consult on the aspects on which the organization will base its decision to acquire a CASE tool, especially those considered critical.
- LISI3 - enabling the results of the measurements of the technological and organizational indicators applied to each of the CASE tools stored to be consulted
- LISI4 - executing the decision model for a specific case given and on the CASE tools selected for the evaluation.
- LISI5 - presenting the results of the basic functions indicated above, in graphical and personalized form.

In addition to these basic functions there are the support and update functions. These are: data back up, help and/or user support, keeping a historical record (additional comments, etc.) and indicator updates, and permitting access from the LISI-KMS (the LISI Knowledge Management System). The development process used was the Rational Unified Process for Web solutions (Ward and Kroll 1999). Figure 6 shows the use case list of the system.

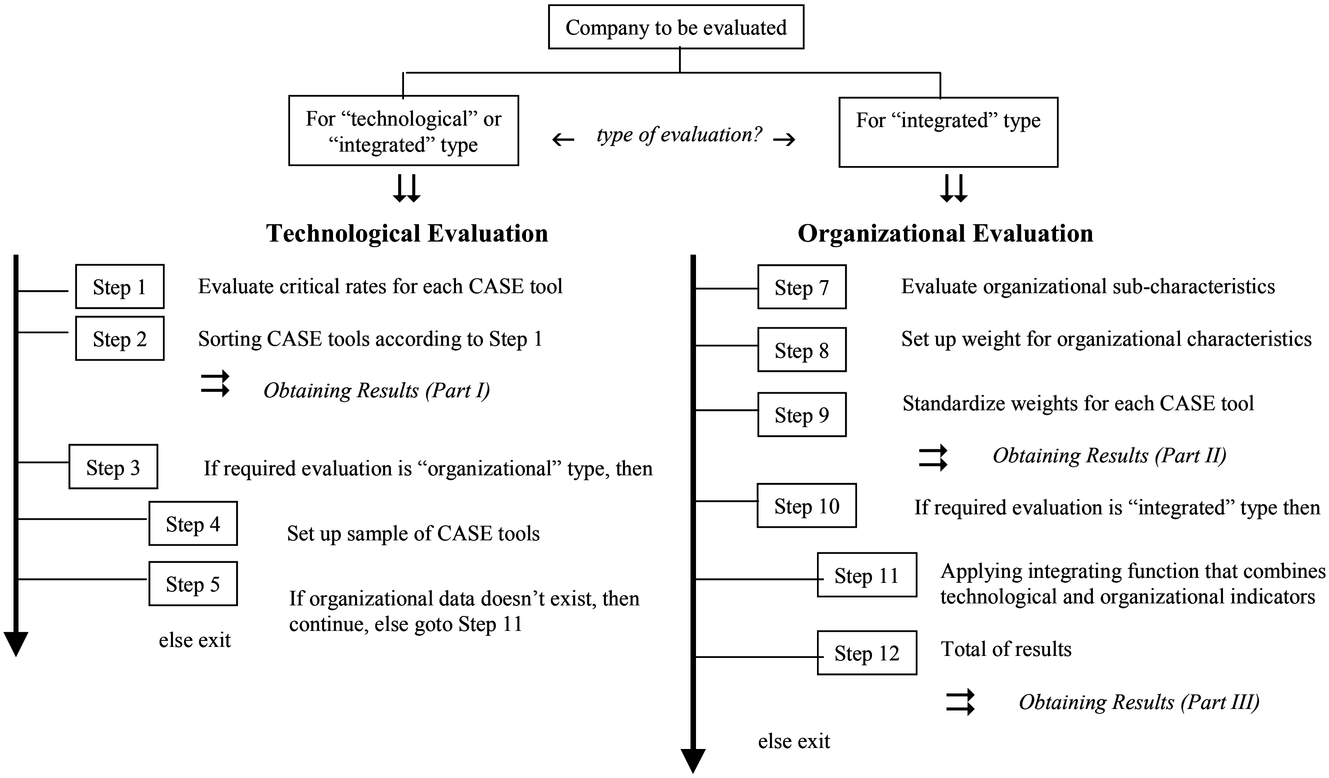

Figure 5. Integrated Decision Model for the Selection of CASE Tools

1. Execute Decision Model
2. Consult Results
3. Manage Data on CASE Tools
4. Manage Data on Critical Aspects according to the organization
5. Get Data (extension)
6. Modify Data (extension)
7. Delete Data (extension)
8. Insert Data (extension)

Figure 6. Use Cases of a Decision Support System for the Selection of CASE Tools

Some non-functional requirements were considered important in the LISI-DSS in order to obtain a quality product since, these were:

- Friendly.
- Shows different choice possibilities according to a case or particular type of company.
- Provides understandable reports, in keeping with the data and evaluation, and customizable.
- Provides reliable evaluations, in keeping with the CASE tools evaluation method.
- Does reliable back-ups.
- Does quick, accurate searches.
- Allows for data insertion facilities.
- Provides clear, precise and easy-to-understand help.
- Enables updates to be done easily and as often as necessary.
- Enables data of interest to be stored in the historical record.
- Can be accessed from the KMS of the LISI, which is accessed from the laboratory web page.
- Secure.
- Effective and efficient.
- High performance.
- Robust.
- Fault tolerant.

The technologies used in this development included Case-Based Reasoning (CBR). CBR searches the memory for cases that have solved similar problems to the present one. After this it adapts the previous solution, adjusting itself to the current problem, taking into account the differences existing between the current and the previous situation (Turban 2001).

Application of CBR when developing a Decision Support System allows for the rapid selection of similar situations to the one presented from a data base of common cases, to facilitate and show decisions reached previously and apply them to new cases requiring decision-making or problem-solving (Turban 2001).

Conclusions and Recommendations

Selecting an appropriate development tool as a means of assuring quality software developed raises a new problem for organizations that undertake this activity. The decision-making process is a complex one that calls not just for the evaluation of the characteristics or attributes of the product or technology itself, but also for a diagnosis to pinpoint the strengths and weaknesses of the organization in relation to the adoption and use of this technology.

The decision model proposed for the development of the DSS compensates for the weaknesses of two models that tackle this problem partially, achieving synergy between the most relevant aspects raised by each of them.

Lastly, this model constitutes the basis for developing a system that enables organizations to make an efficacious selection of a CASE tool capable of contributing towards the quality of the software through the automated support of the essential activities in the development process.

Developing this system has brought us nearer to obtaining a proposal for an integration model that must subsequently be refined through new developments.

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