Quality Evaluation of Economic Decision-Making Support Systems: Oil Industry Case

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ABSTRACT

There is a wide variety of Economic Evaluation-based Decision Support Systems (EEDSS) on the market which are highly complex. Thus, evaluating and/or selecting one that meets the requirements of a particular organization is not an easy task. Additionally the Oil Industry demands Economic Evaluation Tools (EET) that approach its processes as integrated activities: exploration, production and refinement. Based on this need, the objective of this article is to propose a model that helps estimate the quality of the EET using the ISO/IEC 9126 standard as a reference. The proposed model quantifies the quality of the EET's examining three characteristics: Functionality, Maintainability, and Usability, with their corresponding metrics. We have applied the model to three EET's of the oil industry and have evaluated its effectiveness. The model enhances cross-organizational management, since it allows organizations to look at two perspectives: 1) The estimation of quality of EET's already in place in the company and 2) Based on that estimation, establish a criteria for EET selection that meets the company's needs.

Keywords

Quality Model, ISO Standard, Decision-Making Support Systems, Cross-organizational Management, Information System Evaluation.

INTRODUCTION

Master Magazine (2006) defines a Decision Support System (DSS) as a series of applications directed at high executives, which allow for the extraction of strategic company information and – through the use of analysis methods – show projected results derived from the specific decisions made by the users. The validity of the system and its predictions depends on the information given to the DSS and on the application's capability to analyze the data.

The Project Economic Evaluation consists of comparing the economic benefits derived from a particular investment with their corresponding profitability indexes in order to make a decision; given the definition of DSS we may define an Economic Evaluation Tool (EET) as a decision-support system based on economic evaluations of specific projects. These tools compare the economic benefits of an investment with its corresponding cash flow and profitability margins, in order to determine which investment will be more likely to increase the cash-value of the company. To that end, it is necessary to simulate scenarios that consider the company's expenses, products, the estimated production, the investments, the operational costs and the execution master plan.The goal of these tools is to help users (high executives) decide which investment option is more convenient for the organization.

The oil industry is not exempt from this reality; it must select projects based on an economic evaluation through the use of specific tools. The information managed by the EET's is sensitive and critical at a cross-functional level.

The American Society for Quality (2005) defines quality as the totality of functions and characteristics in a product which result in the satisfaction of a particular need. Similarly, The ISO/IEC 9126 (1998), considers that the quality of a software is the result of the totality of those features and attributes of the software product which support its capability to satisfy explicit or implicit needs.

Software-based EET's must then be oriented at satisfying the needs of the oil industry. It is vital for government-owned oil companies to evaluate the quality of the tools that will be used to determine which projects of oil exploration, production and refinement are to be financed.

This article's objective is to propose a quality model capable of quantifying quality in the EET's. This is achieved by looking at three categories: Functionality, Maintainability and Usability. The model allows oil-industry companies to become more efficient and increase the value of the business processes when selecting a project through economic evaluation. The evaluation of the EET is performed at two levels: 1) evaluation of the tools currently used by the company in order to determine which tools adapt to the company's needs, and 2) assessment of which other EET's are essential to meet the company's needs. This is achieved by establishing clear selection criteria based on the quality categories proposed in the model.

The proposed quality model was conceived using the Information Systems Research Lab's (ISRL) methodological framework proposed by Pérez et. al (2004.) This framework, in turn, is based on the Research-Action Method (Baskerville and Pries-Heje, 1999,) and on the DESMET methodology (Kitchenham, 1996.) Finally, the model uses the Goal Question Metric approach (Basili et. al, 1994) in order to develop the required metrics.

The article was written following this structure: first we present a background section which deals with two main topics, the EET's and the product quality model used as the basis for our work. Next we present the proposed model along with an evaluation of it. Finally, we present the conclusions and some recommendation for future works

BACKGROUND

In order to realize this research project we first needed to be familiar with all the concepts associated with an EET as a DSS in the context of the oil industry. We also identified a software quality model to be used as the basis for the proposed model. In the next section we expand on these two aspects of the research.

Economic Evaluation Tools in the Oil Industry

EET's are used in the oil industry to support the decision-making process regarding the selection of projects presented to the oil companies (PDVSA, 2005).

A Project is an investment done in non-recurrent or non-repetitive economic actives. It implies an objective, a scope, a set of costs and an execution timeframe, all which must be well-defined. Projects are completely executable as a unit and they only acquire productive value once they are finished (PDVSA, 2005). Projects also represent investments on constructions which must be finished in order to have any productive value (PDVSA, 1992.)

In order to determine the plausibility of a project, the project must be presented through an *investment proposal*. The investment proposal consists of all the detailed information regarding the project; this information is essential in order for the project to be considered for approval into the company's budget (PDVSA, 2005).
In addition, organizations develop investment plans for those projects that help facilitate processes within the organization.

PDVSA (1992) states that investment proposals can be categorized depending on the type of project and the costs. The proposals are divided in two kinds:

- *Profit Generating Proposals:* These *proposals contemplate projects which save money or alleviate costs. The benefits associated with these proposals derive from the sale of a product or service, which generates a cash profit to the company.*

- *Non-Profit Generating Proposals:* These proposals contemplate projects which generate higher costs.

According to PDVSA (2004) the proposals can also be classified as follows:

- *Portfolios:* These are a set of packets, modules or projects presented by each one of the Units, in order to develop the short/medium and long term plan. It helps identify and establish the different business opportunities, rating their operational execution possibilities.

- *Scenario:* It consists of a series of economic variables which determine the business' behavior. It presents a set of common values for a given portfolio, which are assigned to different variables in order to perform the economic evaluation of the packets and of the portfolio as a whole. In order to simulate the scenario it is essential to have: the expenses, the products, the estimated production, the investments, the prices, the operational costs, and the execution plans.

- *Activities/Plans:* It consists of all the plans and activities for perforation, maintenance RA/RC services, the LGN profiles, natural gas plans, investment plans, production costs and all the non-profit generating activities.

The economic evaluation of a business depends greatly on its projects; their portfolios represent the business' macro organization. The evaluation of a project's feasibility is done by evaluating its investment proposals. The investment proposals help find mechanisms which allow the goods and social services to actively grow. Factors like the existing political environment, the social environment, the economic and technological environment must also be considered when evaluating a particular project.

Baca (2001) points out that each investment study is unique and different, the methodology for evaluation must adapt to each particular project. Baca proposes a methodology for project evaluation which consists of eight steps: Definition of Objectives, Market Analysis, Technical Analysis, Economic Analysis, Social Analysis, Conclusions and Results, Feedback, and Decision about the Investment Proposal. Our Research focuses on the study of the economic analysis of the project; the goal is for the EET's to support that objective.

Additionally, we use a series of techniques that produce financial indicators. A financial indicator is used to show the condition of a particular economic aspect at a particular time. Indicators are more frequently used in economic evaluation performed in the oil industry. Economic indicators are: Investment Efficiency, Efficiency of the Modified Investment, Accumulated Cash Flow, Present Net Value, Dynamic Recuperation Period, Non-Discounted Pay Period (PP,) Discounted Pay Period, Net Discounted Project Profit, Profit by Barrel, Discounted Investment, Cost of Investment, Cost of Production, Profitability Index, Internal Return Rate, Modified Return Rate, Unified Investment Cost, Unified Operation Cost, Unified Return Cost, Cost before ISRL, Cost after ISRL, Tax and Depreciation Participation.

These concepts were taken into account in order to propose the model, since they must be considered by the EET's, The next section shows those aspects regarding quality.

Quality Model Used as a Basis for the Proposal: ISO/IEC 9126

Our Research used as a quality precedent the ISO/IEC 9126 standard, which was conceived to determine the quality of a software product. A norm is by definition a document established by consensus and approved by a recognized organization that provides rules, directives or characteristics for common and repetitive use in activities aimed at reaching an optimal level of order within a given concept (ISO/IEC 9126, 1998.)

The ISO/IEC 9126 standard was developed in an attempt to identify key quality attributes for a software product (Pressman, 2002.) The standard consists of a simplification of the McCall method (Losavio, Chirinos, Lévy y Ramdane-Cherif, 2003), and it identifies six basic characteristics of quality: Functionality, Usability, Portability, Efficiency, and Reliability of the Sub-characteristics. (ISO/IEC 9126, 1998).

The use of the standard as a basis for this research intends to provide an answer to the most immediate need of the Venezuelan Oil Industry, by focusing on the process of selection of EET's. The proposed model is shown in the next section.

PROPOSED MODEL FOR THE ESTIMATION OF EET'S QUALITY

The model for the Estimation of EET's Quality is based on the ISO/EIC 9216 standard. In order to customize the model to our particular problem we adapted it as shown in Figure 1. We describe the process as follows.

Level 0: Dimensions. This level comprises the dimensions proposed in the model: Internal and Contextual Aspects of the Product. According to the total quality matrix (Callaos and Callaos, 1996), the proper interrelationship between the four dimensions guarantees the global systemic quality in an organization

Level 1: Categories. The ISO/IEC 9126 proposes six (6) characteristics of Quality. For the proposed model we create categories and select 3 of the 6. This is done to avoid conflicts; one of the categories is required, that is Functionality. This category is mandatory because it identifies the capability of the software to perform the functions for which it was built. Of the five (5) remaining categories (Maintainability, Portability, Efficiency, Usability and Reliability) we selected two (2). The selection responds to the needs of the organization in regards to EET's. After consulting with the stakeholders it was decided that the model should consider *Usability and Maintainability*.
Usability was chosen because the EET's provide support at various management levels, from the highest level (executive) to the operative level. The EET's can be used in different functional areas and also help support semi-structural decisions. This means that the level of difficulty when using an EET must be minimal. The EET must have the capability of interacting with the user in a friendly manner, and it must be an attractive, easy-to-learn product. It must be easy to use and the user must be able to explore the EET using high-quality charts. It must allow the user to do reports and develop their own decision models even if the user is not really familiar with computer systems.

Maintainability was chosen to comply with Decree number 3390, Article 1, which establishes that: The Public Administration will give priority to Free Software developed using Open Standards in their systems, projects and IT services. To that end, all the organizations and entities of Public Administration will gradually and progressively move toward the use of Free Software developed using Open Standards. This model is proposed specifically for the Oil Industry, and the evaluation of the EET's is performed for a company that is part of the Public Administration. In order to comply with the law, the company must make the move toward free software. EET's are no an exception; the model, then, must abide by the law. The product must be designed to be modified and accept the inclusion of new modules without the need of structural changes.

Level 2: Characteristics. Each category is associated to a set of characteristics, totaling 33. Eight (8) belong to Functionality, eleven to Usability and fourteen (14) to Maintainability

In order to respond to specific needs within the organization we proposed a series of sub-characteristics: nineteen (19) in the category of Functionality. These are shown in Figure 1 and in Table 1, and are highlighted in grey.

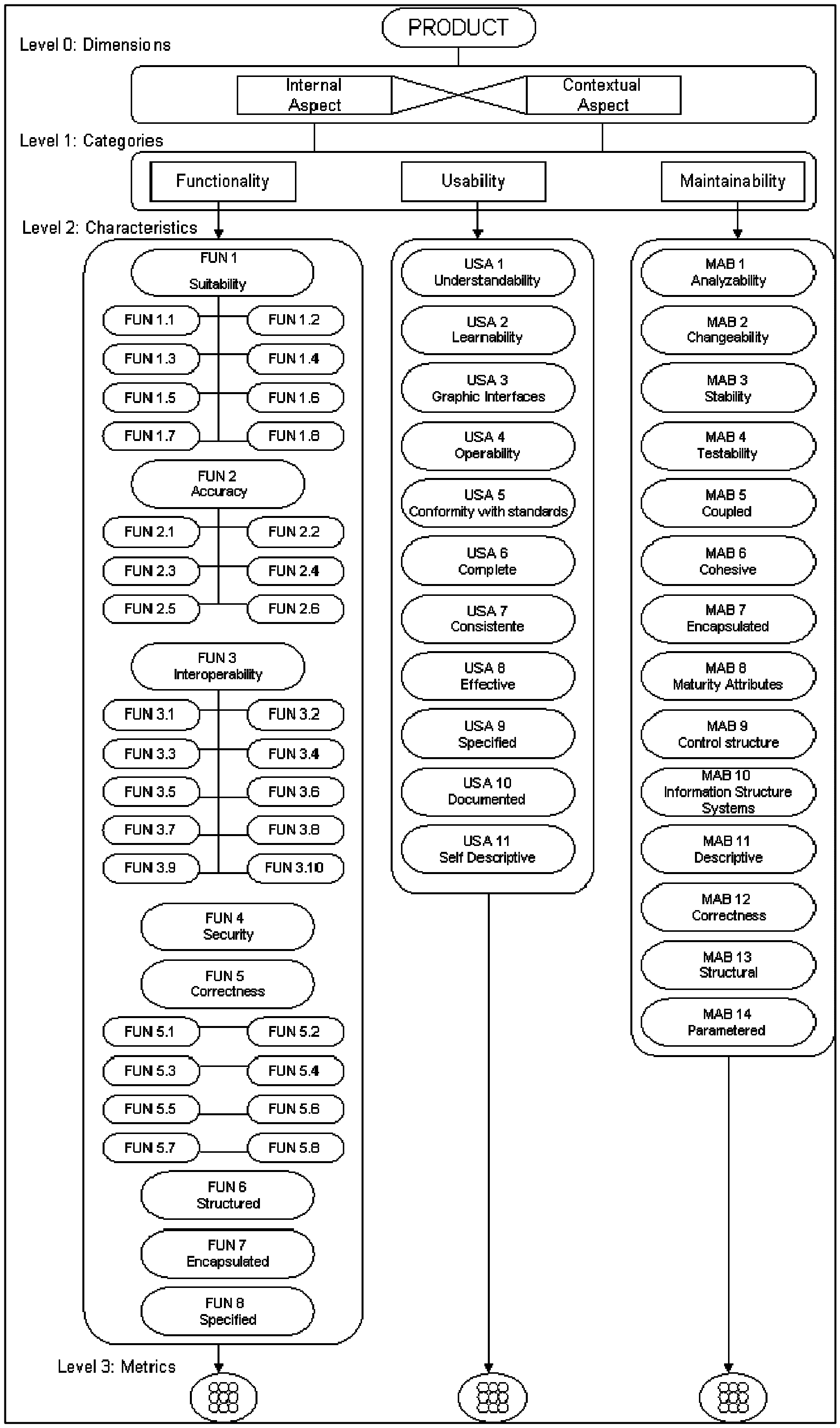


Figure 1. Model to estimate Quality of EET's.

Level 3: Metrics The Model proposes one-hundred and twenty-eight (128) metrics for Functionality, thirty-eight (38) metrics for Usability, and seventy-nine (79) metrics for Maintainability. This level concludes the formulation of the model of quality of EET's. For specifics on the metrics we used the Goal Question Metric approach (Basili et.al, 1994.) Table 2 shows an example of how the approach was used.

CATEGORY	CHARACTERÍSTICS	SUB-CHARACTERÍSTICS
FUNCIONALITY(FUN)	FUN. 1 Suitability	FUN. 1.1 Manage Portfolio FUN. 1.2 Manage Scenario FUN. 1.3 Manage Packet/Project FUN.1.4 Manage Plans/Activities FUN. 1.5 Calculations FUN. 1.6 Analysis Techniques FUN. 1.7 Generate Reports FUN. 1.8 Manage Indexes
	FUN. 2 Accuracy	FUN. 2.1 Complete Results of the Calculations FUN. 2.2 Complete Results of Risk Analysis FUN. 2.3 Complete Results of Sensitivity Analysis FUN. 2.4 Correct Results in the Calculations FUN. 2.5 Correct Results of Risks Analysis FUN. 2.3 Correct Results of Sensitivity
	FUN.3 Interoperability	FUN. 3.1 Compatible with different Operative Systems FUN. 3.2 Export Data FUN. 3.3 Import Data FUN. 3.4 Integration of Excel application FUN. 3.5 Client-Server Platform
		FUN. 3.6 Functionalities used by the system that belong to another system FUN. 3.7 Complexity when switching to another system FUN. 3.8 Functionalities that belong to the system and that are used by other systems. FUN. 3.9 Consistency with the interfaces from other systems FUN. 3.10 Functionalities
	FUN. 4 Security	FUN. 4.1 Detection of user's access to the system
	FUN. 5 Correctess	FUN. 5.1 Computable FUN. 5.2 Complete FUN. 5.3 Assigned FUN. 5.4 Precise FUN. 5.5 Initialized FUN. 5.6 Progressive FUN. 5.7 Variable FUN. 5.8 Consistent
	FUN. 6 Structured	
	FUN. 7 Encapsulated	
	FUN. 8 Specified	

Table 1. Characteristics y Sub-characteristics of Functionality for MOSCA EET. Adapted from (Mendoza et al., 2005).

OBJECTIVE(S)	QUESTION(S)	MÉTRIC(S)	FORMULATION OF THE MÉTRICS	Directed to:
Characteristic	**Sub-characteristic**	**Sub-Sub-characteristic**		
FUN. 1 Suitability	Does the tool manage Portfolios?	Storage of Basic Data	C= { $1 \leq n \leq 5$ where $\begin{cases} n = \lvert S \rvert / 1{,}8 \\ S \subset C \end{cases}$ $\neg$ C = 1 C={ Stores Name Creator, Stores Name Portfolio, Stores Description, Stores Cycle, Stores Business Unit, Stores Product, Stores Type of Portfolio, Stores Hierarchy Stores the type: whether it is project or packet	User
		Basic Operations	$C \wedge D = 5$ $C \wedge d = 4$ donde $\{ d \subset D$ $C = 3$	User

			$\neg C = 1$ *C*={ Allows to Create Allows to Modify, Allows to Consult, Allows to Delete, Allows to Save } D={Allows for Listing , Allows for the Application of Filters, Allows to select destination Folder. , Allows to select origin folder allows to pass the cycle }	
	¿Does the tool manage Plans/Activities?	Basic Data Storage	C= { $1 \le n \le 5$ where $\begin{cases} n = \lvert S \rvert / 3{,}2 \\ S \subset C \end{cases}$ $\neg C = 1$ C={ Store Seismics ,Stores perforation and repairing , Stores RA/RC, IAV, Stores services, Stores other products, Stores LGN, Stores Human Resources, Stores profile of oil rigs Stores balance of gas , Stores investment , Stores production costs , Stores gas production costs , Stores non-profit generating activities , Stores summary, Stores economic evaluation}	User
		Basic Operations	$C \wedge D = 5$ $C \wedge d = 4$ $C = 3$ where $\{d \subset D$ $\neg C = 1$ C={ Allows tot Create, Allows to Modify, Allows to Consult, Allows to Delete, Allows for the Re-calculation of the information, Allows to export from Excel, Allows to export from Excel, Allows to save} D={Allows to insert activity /year ,Allows to Eliminate activity/year, Allows to create lists , Allows to replicate information}	User

Table 2. Example of the Formulation of the metric through GQM.

EVALUATION OF THE PROPOSED MODEL

For the evaluation of the model we used the method of evaluation of characteristic analysis by case study (Kitchenham and Jones, 1997). The method of Characteristics Analysis by Case Study consists of evaluating of the model, after it is applied to an actual software project. Figure 2 describes the steps taken in the method. Figure 2 also shows two important processes. First, every Characteristics Analysis must follow these steps: defining the scope of the evaluation, defining the basis for the evaluation, defining roles and responsibilities, defining premises and restrictions, defining timeframes and required effort, and finally applying the chosen evaluation procedure.

Given that the research is done in the context of the most important oil company in the country, we were able to apply the method to three case studies using three EET's. Due to confidentiality restrictions we shall dub the EET's as A, B, and C. We briefly describe them next.

- EET A: Allows for the quantification of the profitability of an investment project through the economic indexes. This application was developed by the organization.

- EET B: Capable of generating work portfolios consisting of Packets, Modules, or Projects which contain development plans for the different Units of Perforation. This application was developed by the organization.

- EET C: Capable of performing economic evaluations in a deterministic manner and with option to an analysis under risk conditions, modeling any tax system in the world.. This application possesses a commercial license.

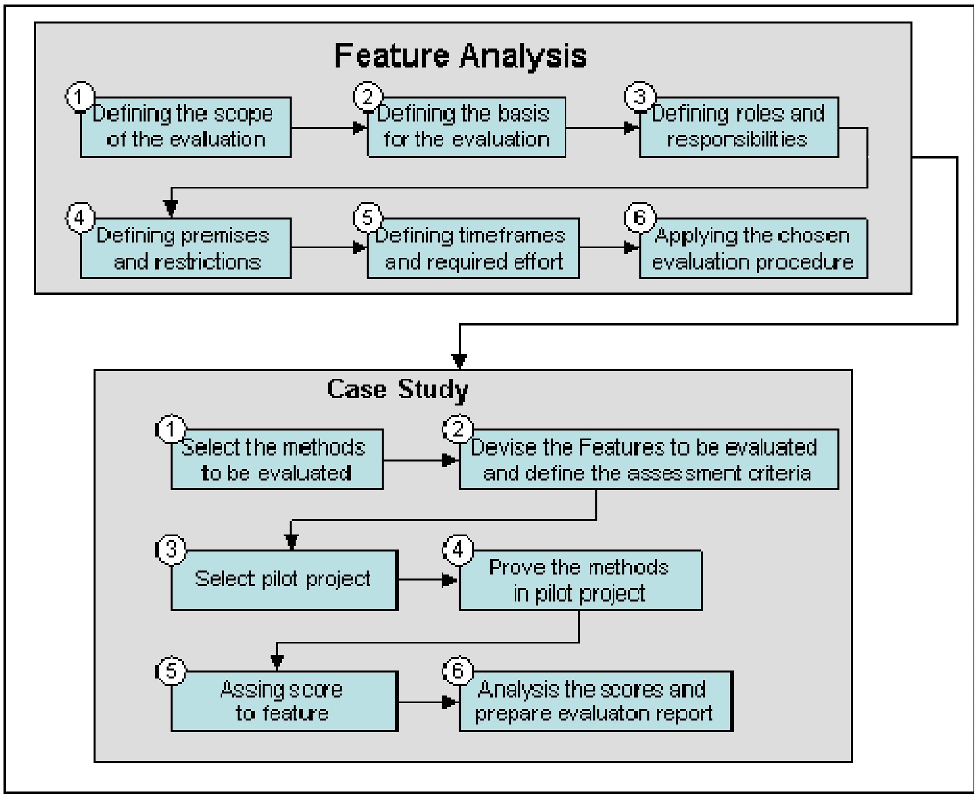


Figure 2. Steps of the Method of Evaluation Analysis of Characteristic by Case Study

In accordance with step two of the Case Study, Identifying the set of characteristics to be evaluated and defining the accepted criteria; we selected a set of characteristics which allowed us to effectively evaluate the model for the EET's. These characteristics go from the most general (such as pertinence of the survey applied, completeness of the involved categories, adequacy to the context and precision of the level of quality specified by the survey), to the specific (metrics and their pertinence, plausibility and their level of depth and scale).

We formulated, then, two questionnaires: one to evaluate the characteristics of the model, and one to evaluate the quality of the three EET's. These questionnaires were answered by the Project Leader, by the Developers/Analysts and by the users. The analysis of the results of both questionnaires is detailed in the next section.

ANALYSIS OF THE RESULTS

Results of the Evaluation of the Proposed Model

The evaluation was performed only for the category of Functionality, since this category was the only one which underwent modifications according to the type of application. The other two categories (Maintainability and Usability) are similar for the majority of the software. Figure 3 shows the results of the each of the general characteristics. These were met in their entirety (100 %). The evaluators considered the model **Pertinent** within the scope of specification of software quality. The sub-characteristics and new metrics are **Complete**. The context of the sub-characteristics and metrics was considered to be **Adequate** and their level of specific quality **Precise**. This indicates that the adaptation of the evaluation method for the EET's is generally considered **Accepted**.

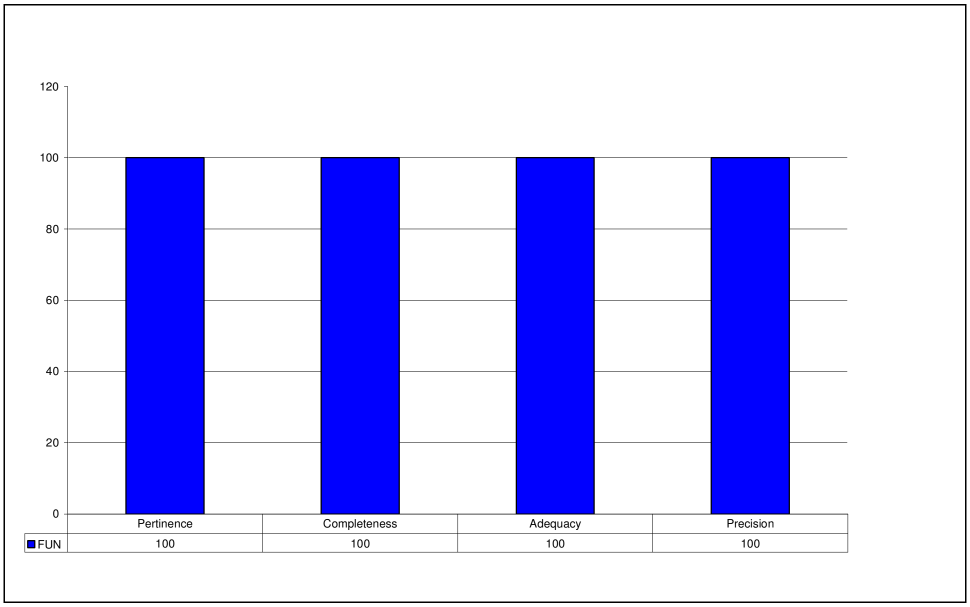


Figure 3. Results of the Evaluation of the Proposed Model at the General Characteristics level.

The results at the specific-characteristics level are shown in Figure 4. The evaluators of the EET B considered that the metrics rate at 95% for depth and at 98% for scale. For the rest of the specific characteristics in all the EET's that were evaluated, the evaluators rated at 100%. The criteria of compliance rated at a 75% for the Analysis of Characteristics. The Functionality for the proposal was considered **Acceptable**.

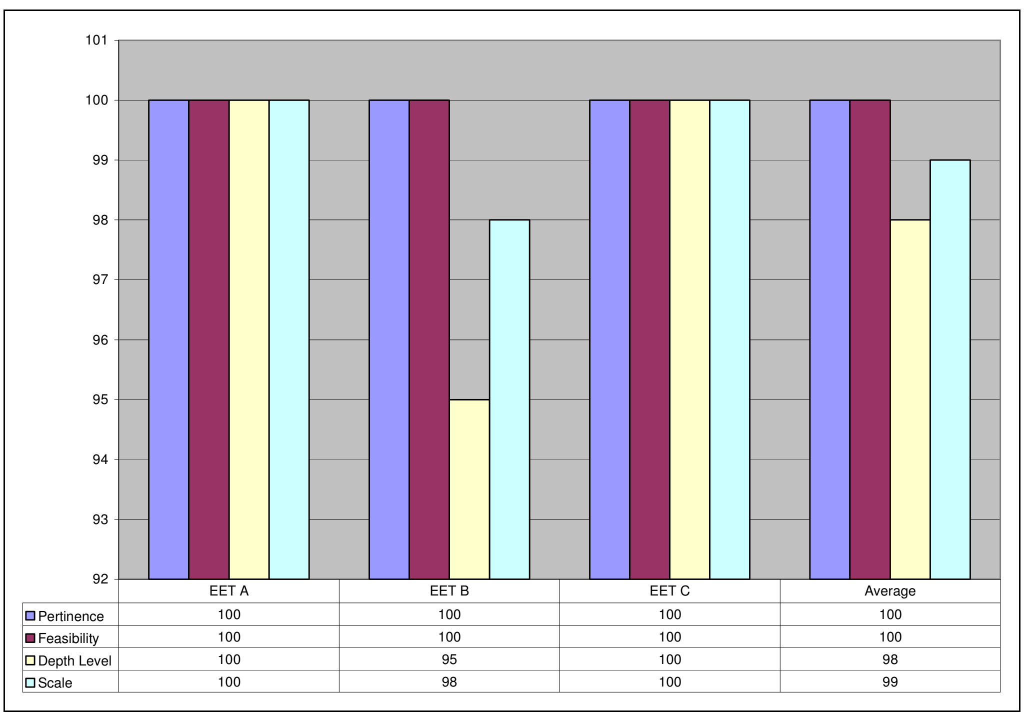
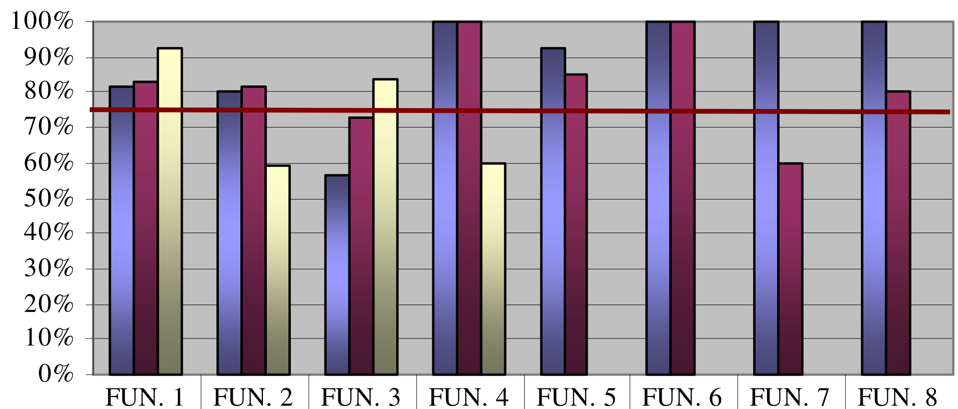


Figure 4. Results of the Evaluation of the Proposed Model at the Specific Characteristics Level

Results of the Evaluation of Quality of the EET's

Figures 5, 6, and 7 show the percentages reached for each one the EET's regarding the quality requirements associated with Functionality, Usability, and Maintainability.

As evident in Figure 5, for the **EET A**, seven (7) of the eight (8) characteristics meet at least 75% of the satisfaction requirement. Only FUN 3 (interoperability) was not met. The algorithm of application establishes that at least six (6) of the characteristics must be met with a minimum of 75% for this category to be satisfactory. Therefore the category of Functionality is considered **satisfied** for **EET A** and **EET B**. For **EET B** only the characteristics of FUN. 3 (interoperability) and FUN. 7 (Encapsulated) are not highly satisfactory. For **EET C** we omitted the characteristics corresponding to the internal aspects of the product, given that **EET C** is a licensed product. This tool did not obtain 75% satisfaction because ideally it would meet at least three (3) of the four (4) evaluated characteristics, and only two (2) rated higher than 75 %, namely, FUN.1 (Adjust to Purpose) and FUN. 3 (Interoperability). As a result, and according to the Algorithm (Mendoza et al, 2002) *we cannot continue with the evaluation for C*, because the category of Functionality was **not satisfied**.



	FUN. 1	FUN. 2	FUN. 3	FUN. 4	FUN. 5	FUN. 6	FUN. 7	FUN. 8
A	81,32%	80%	56,53%	100%	92,50%	100%	100%	100%
B	83,29%	81,60%	73%	100%	85%	100%	60%	80%
C	92,68%	59,20%	84%	60%	0%	0%	0%	0%

Figure 5. Percentages of satisfaction reached by the evaluated EET's in the Functionality category

The algorithm for the application establishes that at least eight (8) of the eleven (11) requirements must be met in order for Usability to be satisfied. As shown in Figure 6 **EET A** met nine (9). Only USA. 1 (Easy to Understand) and USA. 3 (Graphic Interface) were not satisfied. Regarding HEE **B** only USA. 1 (Easy to Understand) was not highly satisfied. With these results we considered the category of Usability to be **satisfied for both Tools A and B**.

The algorithm of the application establishes that at least eleven (11) of the fourteen (14) characteristics for Maintainability must be met. Figure 7 shows that **EET A** met eleven (11) of the characteristics; only MAB. 1 (Analyzability), MAB. 5 (Coupled) and MAB. 10 (Information Structure System) were not satisfied. We consider the category of Maintainability satisfied for A. EET B met eight characteristics, MAB.1 (Analyzability,) MAB 4 (Testeability), MAB. 5 (Coupled), MAB. 6 (Cohesive,) MAB 7 (Encapsulated) and MAB 8 (Attributes of Maturity of the Software) were not highly satisfied. We considered the category of Maintainability **not satisfied for B**.

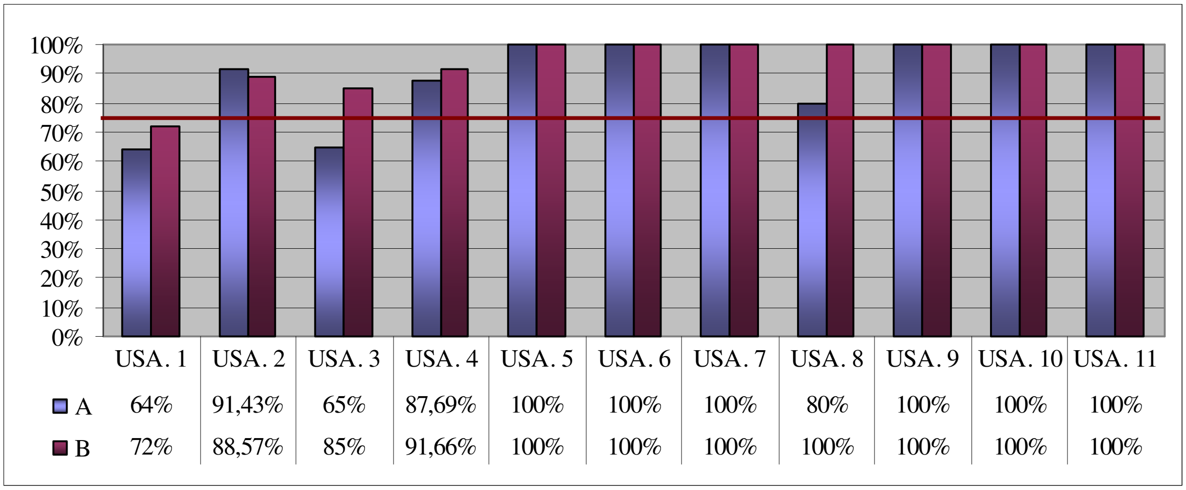


Figure 6. Percentages of satisfaction reached by the evaluated EET's in Usability

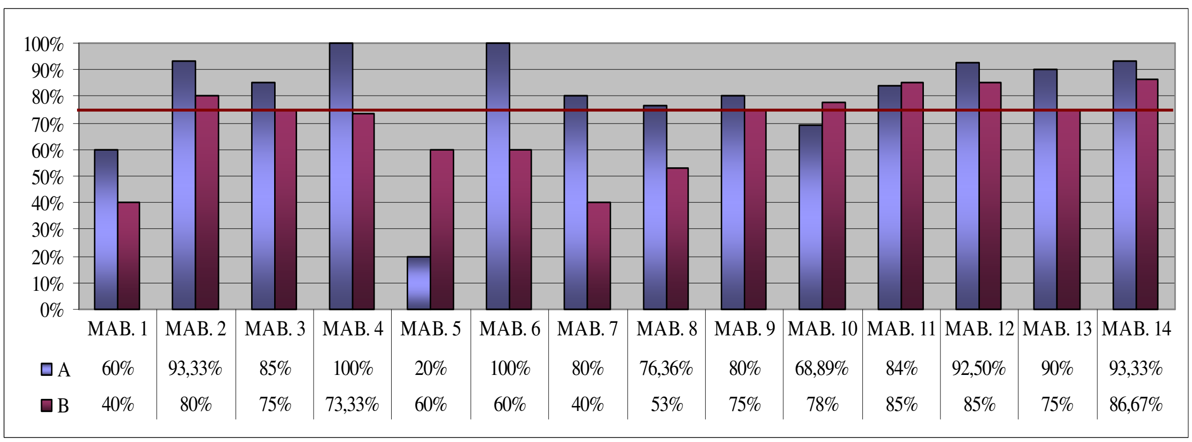


Figure 7. Percentages of satisfaction reached by the evaluated EET's in Maintainability.

Following the standards of the algorithm of the application of the proposed model we conclude that **the quality of the product for the EET A is Advanced**, since it satisfies all three categories. **The quality of the product for the EET B is Intermediate**; it only meets two (2) of the three (3) characteristics, namely, Functionality and Usability. Finally **the quality of the product for EET C is void** because the most important category (Functionality) was not met.

We conclude then, that the EET that can adapt to the business, exploration and production of PDVSA is EET A. Of the tools evaluated EET A rates above 75% in all its characteristics and possesses an advanced level of quality.

CONCLUSION

Through this research we have proposed a model of quality based on standard ISO/EIC 9126 that supports the selection of Economic Evaluation Tools for the Exploration, Production and Refinement of Oil Industry. The proposed model for EET's incorporated 128 metrics for Functionality, 38 metrics for Usability and 79 metrics for Maintainability.

In addition, we were able to apply the model to three (3) EET's used in the oil industry; we evaluated the quality of this tools and focused on how the best-rated EET is the one that adjusts best to the company. By applying the Case Study for Analysis of General and Specific Characteristics we proved the effectiveness of the proposed model.

We recommend that the research be continued and extended to other companies of the oil industry. We also recommend that those characteristics which did not reach 100% be revised for the proposed model.

ACKNOWLEDGMENTS

The authors wish to thank to Alexandra Ñañez and Jennifer Gudiño for their contribution to this research.

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