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Discrete-event simulation software selection for manufacturing based on the maturity model

Alexandre Magno Castañon Guimarães, José Eugenio Leal*, Paulo Mendes

Pontifical Catholic University of Rio de Janeiro, Brazil

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ABSTRACT

The main objective of this research is to develop a new method to help an industry select the right DESS (discrete-event simulation software), which helps improve the productivity of a given process.

This paper addresses this issue by developing a methodology that undertakes two aspects of the problem. First, it proposes a methodology that allows for companies to self-assess their current internal processes based on a maturity model to identify where they stand in the maturity continuum for simulation. Second, it applies the analytical hierarchical process (AHP) to support simulation software selection by detailing and weighting the components that are important for the specific company to meet its business objectives. To the best of our knowledge, there are no other studies that combine these two methodological tools to help decision making for DESS selection.

1. Introduction

According to Koch et al. [1], companies must continually adapt to the needs of the market. In order to do it effectively and efficiently, production resources must be organized in a planned manner.

Authors, such as Sandanayake et al. [2], Sandanayake and Oduoza [3],Azadeh and Maghsoudi [4], Sawant and Mohite [5], Bosch-Mauchand et al. [6] and Rakiman and Bon [7], note that computer simulation is one of the most advanced and powerful tools for modeling and analyzing operational performance in companies to support continuously adaptation.

However, before computer simulation is adopted, companies should satisfy certain basic conditions. One way of assessing whether these conditions are met is through maturity models, which can be used to measure the quality of a company's processes and the extent to which the technicians are qualified to implement the software and exploit its full potential.

There is a wide range of simulation software packages available in the market. They provide a variety of applications, have different prices and features and use different approaches and modeling strategies. This increasing choice of simulation software makes the task of selecting a suitable product a difficult one. An incorrect choice of software can have undesirable consequences, such as financial losses, longer modeling times, project interruptions and a lack of suitable resources, leading to poor decisions and, consequently, poor organizational performance. Adopting the correct approach when selecting simulation software is therefore essential [8,9].

In this scenario, characterized by increasing use of simulation software to evaluate production processes, and a wide range of softwares available in the market, methods for evaluating and selecting discrete-event simulation software that is suitable for a company's particular circumstances are clearly important.

The main objective of this research is to develop a method to help an industry select the right DES software (discrete-event simulation software), which improves the productivity of a given process.

This study presents a model for the evaluation and selection of simulation software with the support of a maturity model as its main academic contribution. Additionally, it captures, in a structured manner, the criteria to identify critical simulation software features for managers in manufacturing companies. To the best of our knowledge, there are no other studies that combine these two methodological tools to help make DESS selection decisions. Along the paper we presented literature reviews on maturity models in section 3.2 and on software selection in section 3.3. From our point of view, this section aims to give an overview of the state of the art of the main experiences described in the literature in each of those topics. From those reviews, we could conclude the originality of the combination of these two methodological tools.

* Corresponding author at: R. Marques de Sao Vicente 225, DEI, Rio de Janeiro, 22453-900, Brazil.
E-mail addresses: alexcastanon@skydome.com.br (A.M.C. Guimarães), jel@puc-rio.br (J.E. Leal), pamendes@coca-cola.com (P. Mendes).

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The article is organized in six sections, including this introduction. Section 2 describes the methodology applied in the study. Section 3 consists of a review of literature on maturity models and the selection of simulation software; the review forms the basis of the proposed methodology. Section 4 presents a method for evaluating and selecting simulation software. In Section 5, the proposed methodology is applied, and the results of the analysis of the processes and the software selection are detailed. Finally, in Section 6, the conclusions about the results and contributions made by this study are formalized.

2. Study methodology

Yin [10] stated that there are three types of case studies: exploratory, descriptive, and explanatory. While experiments try to answer research questions as who, what, where, why, or how, which require control over the events and focus on contemporary events, a case study does not require control over the events and is more appropriate for the questions of how and why. Case studies include direct observations and systematic interviews. A case study has five components: i) the questions of the study; ii) the propositions; iii) the units of analysis; iv) the logic that links the data to the propositions and v) the criteria to interpret the findings.

The methodology used to develop the research had following steps:

1 Define the research issue: how can companies select the most adequate DESS for the manufacturing industry?
2 Conduct a literature review on the causes of success or failure when using DESS in the manufacturing industry.
3 Based on that first review and the author's direct observations, a hypothesis is formulated on the relationship between the level of process development and chance of successful DESS implementation.
4 Define the solution strategy to formalize a self-assessment procedure of the level of process development in the industry in the form of a maturity model. Additionally, a multicriteria decision making methodology—the AHP method—was defined to guide software selection.
5 Conduct a literature review on maturity models and DESS selection methodologies.
6 Build a maturity model. Define the threshold capability characteristics that describe a company successfully using DESS.
7 Build a structured framework to characterize the components of DESS according to the issues faced by the manufacturing industry.
8 Build an AHP model based on the criteria and subcriteria and their weights defined by DESS experts.
9 Apply the maturity model to four companies using a questionnaire. Identify companies that fulfill the basic requirements for using DESS.
10 Use the questionnaire to evaluate the three main software available in the market and translate those answers to the AHP method framework.
11 Analyze the validity of the hypothesis and draw conclusions on the strengths and limitations of the methodology. The main criteria for the validity of the model is the perception of the evaluation group in the companies about the correctness of the maturity model and the software selection procedure.

Considering the definition of Yin, our approach cannot be defined as a pure case study because the first part of the research aimed at developing a two-step decision-making method: i) conduct a self-evaluation of the company with respect to the maturity of its processes and ii) evaluate the components of the software to serve as the criterion for choosing the most suitable software. Once the method has been defined, we can consider our study as two exploratory case studies: one with four units of analysis (the self-evaluation of maturity) and the other with three units of analysis (the evaluation of the software components). For each case study, the research questions are as follows: i) how does the company evaluate its processes, and ii) how does the company evaluate software components according to its objectives? For each case study, a questionnaire was build, and the target group of the questionnaires was defined. The questionnaire was evaluated in terms of the validity of the methods. Fig. 1 depicts the protocol for the case studies.

This research can be considered a design-oriented methodology as defined by (apud Mendes [37]). The approach deals with "how" questions with the goal of designing a model to solve a given problem as stated by (apud Mendes [37]). The application of the method follows a design-testing approach used in traditional empirical sciences as stated by Eisanhardt [11] in his work on the theory of case studies. More of the research methods applied to building maturity models can be found in Mendes [37].

To apply the proposed model, four different companies operating in different market segments were selected. For each company, questionnaires were completed by the manager responsible for the operating unit, and the results were presented and discussed in a group consisting of the manager, the person responsible for the processes, and the person responsible for systems.

3. Literature review

3.1. Conditions for a successful DESS implementation

Johansen et al. (2003) present a study with the purpose of determining why DESS was less successful than predicted by many experts. They analyzed 16 industries and concluded that the main reason was the lack on the right kind of information at the right time due to inadequate practices within the organizations. They conducted their analysis from the point of view of the requirements for a successful implementation of DESS as a daily tool in the companies; however, those requirements are tied to the level of process structure in the industries including the information system.

Ingamansson et al. (2002) present the results of a survey on using DESS that includes 80 companies. They comment that larger companies have better adaptability in using DESS than smaller firms. They stress that a successful project involves not only knowledge about simulation software but also adequate production improvement techniques, which are, in general, expected to be more developed in larger firms.

Norouzilame and Jackson (2013) focus their work on the proposal of a framework to successfully implement DESS. They suggest that two types of competence are required to apply DESS: knowledge of the system to be simulated and simulation expertise, which include modeling techniques and DESS project management

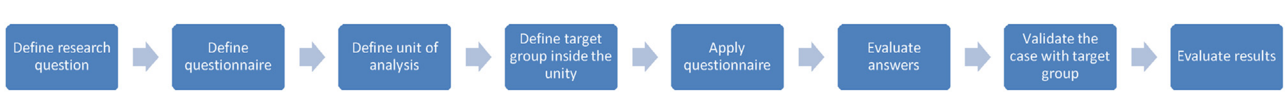

Fig. 1. Protocol for a case study.