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DEVELOPMENT OF A NEW LEARNING METHODOLOGY FOR DISCRETE EVENT SIMULATION BY REUTILISING PREVIOUS SOFTWARE EXPERIENCE

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Abstract

New discrete event simulation software available to industry has significantly reduced the modelling efforts of complex manufacturing problems. These tools enable analysts to assess the viability of potential solutions that better conform to previously defined requirements. Thus, analysts must be conversant in new technologies applications to deliver top quality solutions to the enterprises analysed.

Traditional approaches of learning a new technology tend to isolate previous knowledge the analyst possesses in similar application fields and concentrate on features and strengths of the particular application under study. A new approach is therefore needed to capitalise on previous experience an analyst might have, enabling reduction of learning a new technological application by minimising the learning curve effort spent learning the technology, and increasing focus on quantitative and qualitative analysis.

The focus of the present research is to reutilise previous experience in a particular research field, i.e., enterprise modelling and discrete event simulation, current researchers possess to adopt a new technological application. Utilising previous case study's information, researchers created models within the new technology application reutilising previous experience modelling in a particular technology. This enabled researchers to focus on the analysis and the strengths of the new technology rather than to relearn how to model in a discrete event manner thus becoming conversant with the technology application.

By reutilising skills and experience previously acquired by researchers, it has been possible to reduce the effort in learning the new technology and to shift attention to the original problem complexities to produce more detailed analysis of the situation.

The focus of the paper is not to solve particular requirements of the case study, but to develop a new approach to learn new technologies.

Transferring previous experience into similar environments enables minimisation of efforts in the learning curve and allows the student to adapt rapidly to the requirements faced. Change resistance, present in most cases, is minimised as students realise the knowledge they had can be re-used.

Keywords: Discrete event simulation, Models, Learning, Knowledge transfer

1.0 Introduction

Simulation software for discrete event simulation (DES) have enabled practitioners and researchers alike to model, document, experiment and validate requirements posed by manufacturing enterprises (MEs) systems with increasing levels of complexity. There are several technological applications that can analyse dynamic behaviours inherent to the ME's production system. Simulation models are used to analyse current state environment while also being used more proactively for the development of potential candidate solutions that best conform with a proposed strategic intent. Comparisons can be made of variables defined by the analyst, such as throughput, station utilisation, working times, etc. In an increasingly competitive global market, there is a consensus that ME's need to realise their productive activities maximising current resources and being capable of realising any potential change in said environments rapidly. Therefore, researchers and practitioners alike faced to learn state of the art software packages that provide more descriptive models that better capture organisational requirements and proposed candidate solutions.

As discrete event simulation software applications have evolved, new and distinctive sets of tools are offered to the user that facilitate increasingly more complex multiple perspective analysis of a portion of the enterprise understudy. Although basic operations within those applications perform similar functions, distinctive characteristics separates them. The analyst must be conversant in the different features that each package offers so that it may provide the best solution to the problem domain it tackles. The choice of software the analyst does will be directly affected by the tools offered and by the requirements the organisation poses. The analyst will need to be aware of the different software applications that are available, so as to choose the one that which will deliver the maximum benefit to the organisation understudy.

Most software packages include several aids that help the user learn the functionality of the package and guide him through simple tutorials that demonstrate key aspects within a reduced complexity case study. However the experienced practitioner or researcher finds themselves increasingly frustrated at the simplicity of models and disjoint from the help material provided in such software programs which in turn hinders progress to develop a coherent set of models that capture an organisation's requirements or that detail a potential candidate solution. Most materials are aimed at users with no experience whatsoever with similar packages or knowledge within the particular field, i.e., financial background of an experienced user when learning the functionality of a spreadsheet. Learning a state of the art application should benefit from the experience in similar applications and from the knowledge that the average user of such technologies has in the field. By reusing such experiences and knowledge, the typically experienced learning curve in such situations can be minimised, reducing change resistance impact will also be greatly reduced and performance can be enhanced.

2.0 Current Literature Review

Acquisition of skills in a relevant software product is essential in today's working environment. As technology advances rapidly, increasing pressure is centred in learning state of the art applications within a constrained timeframe[3]. Support material has been evolved from textual, i.e., instruction manuals to presentations and reduced functionality software that has enabled students to learn an application [1]. These materials have greatly enhanced the learning experience and have improved the understanding of the application by the student. However, design of such materials has been developed with experimental groups in which individuals possess little or no experience utilising similar applications[1] and [3]. Most of the learning an individual or organisation does come through experience [2]. Increasing amounts of research has been directed towards the processes that occur in learning and knowledge transfer [7]. The role of previous experience in related areas of knowledge has been closely linked to a successful transfer of knowledge in the organisation, and has also been related to a systematic learning from past experiences[7].

Several factors have been identified to produce change resistance within an organisation [4]-[6]. Amongst these causes, technological implementation and the potential employment related risks contribute to an increase from various levels of the organisation to resist such a change. Planning changes in an organisation can potentially mitigate the effects of change resistance, such as low performance from the system. Most technological changes have improved the quality of life, but some have an adverse impact on the workforce, i.e., layoffs [4]. It has been suggested that the change rate in which alterations occur in modern society has outweighed the societal capability to respond leading to the well know adage: "Change is the only constant thing"[4]. However such change resistance can be managed to improve the chances of successful change implementation within an organisation. Several course of action can be implemented in an organisation to reduce the impact of change resistance and assure a successful implementation of a technology. Training, both conceptual and practical, are amongst the suggested activities needed to achieve success. [6].

3.0 Proposed Approach

Previous sections have highlighted the potential pitfalls utilising the traditional methods of teaching a new software application. With increasing pressure from academia and industry to utilise discrete event simulation software applications to provide optimal solutions to an evolving set of requirements, it follows that there is a need to reduce time spent in learning a new software application. The methodology set forward in this section addresses the issue of reutilising previous knowledge and experience to learn more rapidly a software application and decrease change resistance to embrace a new software application.

MSI Research Institute at Loughborough University has several years of experience utilising simulation modelling and discrete event simulation software in various projects across different industries. The group has used several software applications and has a range of knowledge and experience in applying discrete event simulation software. The authors considered that the collective and individual experience of the MSI Research Institute provided an ideal control group to trial a new learning methodology.

Several discrete simulation software packages have been utilised in the past by members of MSI Research Institute. Software packages such as SIMUL8, Witness and Arena form the principal collection of tools used by the control group, to create complex discrete event models of several case studies. New research interest acquired the UGS Tecnomatix suite, which includes the discrete event simulation tool Plant Simulation. The authors identified this new tool as comparable to SIMUL8 package, which is the main modelling tool utilised by the control group, and therefore presented an opportunity to trial a new learning approach to modelling and simulation on the test set who had little or no knowledge of Plant Simulation software.

Previous experience of the authors when teaching a new technology, highlighted the need of students to find common ground with the known technology application. Throughout a series of courses the authors imparted, the need of relating to previous knowledge or experience was evident in facilitating learning of the new technological application as well as reducing change resistance to adapt a new technology. Therefore it was evident that a new learning methodology that included the reutilisation of previous knowledge was needed to successfully teach new practitioners on a particular technological application.

The methodology consists of thee steps to reutilise knowledge in learning a new software application. The first step is to compare functional, operational and informational capabilities in SIMUL8 and Plant Simulation. A gap analysis is performed to elicit and compare characteristics inherent to both applications is needed to identify which capabilities provide similar functional characteristics. Characteristics that are not common to both software applications can be related to previous experience or knowledge.

After the gap analysis between technologies, the second step explores the commonalities between software packages under review and highlights areas in which knowledge can be reutilised. The objective of this stage is to identify those capabilities that are common and in which potential knowledge held by a user of the first software package can be utilised to learn the second.



Fig. 1. parative areas of steps 1 and 2

Third step is to design training materials considering previous knowledge and experience held within the control group. Such information can be elicited in a number of ways, such as, questionnaires, electronic correspondence etc.

4.0 Application of Methodology

The authors previous knowledge of both discrete event simulation software packages and detailed information on the case study previously developed enabled the design of course materials to effectively train researchers at the control group in the software application. The case study developed dealt with the process network of activities of a small manufacturer in the furniture industry. Several models were created to elicit requirements and develop potential candidate solutions. Several areas of interest were modelled to understand the current situation and to gather a more holistic view of the ME. It should be noted that the present paper does not go in to detail of the enterprise or simulation modelling developed for such case. Yet it benefits from the models created as a baseline to introduce a new technological application.

The first step towards creating the course materials was a comparison of each software package, i.e., how does each software application accept parameters to develop models. Similar sets of activities within the software package were compared in order to assess the information needed. Components of the previous software package were mapped into the new software. Table 1 presents a capability mapping done between software applications.

Capabilities	SIMUL8	Plant Simulation
Work Centre	Single operation	Single/Multiple operations can be modeled
Processing times	Statistical	Statistical
Entry points	Single production unit can be processed	Multiple production units can be processed
Exit Points	Accept multiple production units types	Accept multiple production units types
Resources	No construct	
Human modeling	Number of workers and shifts	Number of workers, services provided, efficiency, shifts
Model statistics	Inside each object within model	Inside each object, can be presented in an external graph
Graphical display	Within objects	External graphical display can be processed
Hierarchy	Only graphical	Reusable objects
Programming	Modifies unit behavior	Modifies units, production flow, object behavior

Table 1 Mapping of capabilities between SIMUL8 and Plant Simulation

The second step was to focus on similarities presented between specific tools and methods Plant Simulation offers and mapping previous knowledge held at the control group in similar areas of interest. As there is a veritable wealth of experience in simulation modelling and discrete event simulation, this enabled the focus of the course materials to be on the new capabilities that Plant Simulation offered. Therefore, course materials were oriented to analyse a known case study with a different set of tools.

The third step was to develop the course materials emphasising commonalities. A questionnaire was sent to the control group with three four sections: simulation modelling, discrete event simulation software application proficiency, programming languages and statistical knowledge. The responses facilitated the assessment of capabilities presented within the control group. Development of materials and focus of the training sessions was benefited This led to a reduced level of stress as members were familiar with the model to be represented. The focus of the course was to diminish the change resistance that was perceived by the introduction of the tool by some members of the Institute to adopt new technology.

An existing case study previously addressed by members of the control group was utilised as a baseline to teach the new software packages. The models presented in Fig. 2 and Fig. 3 represent a portion of the ME, a small furniture spray shop, modelled with different software packages. To familiarise the reader to the models presented, a brief description of the process networks is provided The ME produces a wide range in furniture products that are categorised by functionality, colour, finishing, etc. In the spray shop, products are categorised into two main groups: Basic Colours and Sienna/Newhaven as these groups follow two different production routes as the Sienna/Newhaven category undergo additional operations. All product types share the production resources within the ME. The modelling exercise consisted in repeating models created beforehand in Plant Simulation. It should be noted that it is not the intention of the authors to present the results or capabilities of the software packages, rather, to illustrate the reuse of experience and learning obtained utilising the proposed methodology. This is provided so that the reader might observe similarities between the software applications and abstract into teaching any software application of a given area to users who possess previous knowledge and experience.



Fig 2. Model of a spray shop captured with SIMUL8



Fig. 3. Model of a spray shop captured with Plant Simulation

Fig. 2 illustrates model created utilising SIMUL8 by a member of the control group. Fig. 3 illustrates the model created with Plant Simulation during the course of the session. Models served as a baseline of knowledge that

individual members have to further study the functionality and resources the new technology offers to their research interest. It should be noted that the models presented do not present the overall picture of the ME understudy, but enabled the researchers to obtain additional insight into the benefits of the new software application.

5.0 Outcomes of Learning

Members of the control group achieved a significant decrease in time spent in learning the software application. Previously, a two week period time was necessary to get a basic knowledge of the software. This was reduced to a week of training to facilitate creation of simple working models. The time difference enabled members of the control group to explore additional capabilities of the application that better suited their research interest. This methodology facilitated a 'hands on' approach, which enabled a reflection and a comparison between capabilities, strengths and focus of the current and new technological applications. Such an approach proved useful as participants could relate from their research or past areas of expertise to comprehend concepts that are not present in the current software application but can be present in other instances.

Change resistance was reduced as members readily adopted the software application as benefits could be observed in the additional capabilities the package offers. Transition from SIMUL8 to Plant Simulation was perceived to be far smoother. Because the training materials provided to the control group were tailored to their experience users quickly established familiarity with the new software as a result of relational learning to previous knowledge.

6.0 Conclusions

As there is an increase of simulation software available to academia and industry, there is a need for new methodology to improve the effectiveness of learning of such applications. Reutilisation of previous knowledge enables a rapid learning of a new software application by sharing common elements of both packages which minimises the effort spent in learning a new software application. By utilising a previously modelled case study, researchers were able to concentrate on the particulars of the software package and obtain new understandings of the future states proposed as a solution.

Application of the proposed methodology in the design of training materials enabled participants to learn the material quicker as concepts were explained within the collective background. This eliminated the need of lengthy explanations or introductions to simulation modelling and discrete event simulation concepts. There was a significant reduction in the time necessitated to create a new model. Members of the control group created models from a previous case study with little or no assistance and could develop further analysis to that which it was previously realised. Positive feedback was received concerning the difficulty of learning the new software application. However, several potential pitfalls were observed. Detailed knowledge of the candidate technological applications is required to compare and assess similarities in such a manner that course materials might be developed. The authors have experience utilising both technological applications which facilitated the development of the training material, Knowledge of participants is also required, this can be time consuming as well as problematic. In the present case, as the authors knew well the participants, this was not an issue. The number of participants in the present study did not allow for a statistical comparison as to provide improvements in creation time. Consensus was reached that reutilising their previous knowledge was a key factor in reducing time spent in learning the new software application.

The authors consider that such an approach when developing training materials can be beneficial for the wider industry as this can be deployed when training employees to a new software application. It can be concluded that such an approach has potential to be deployed across other areas, such new equipment training. The reader can observe that in deploying a new software tool, knowledge and experience reutilisation will enhance performance as well as reducing change resistance factors that are present. Although such efforts can be perceived as an 'ad

hoc' training, it can be argued that benefits of such approach outweigh those of a generic deployment and training.

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