Business Process Modeling Using an Interactive Framework for Immersive Research, Support and Training (I-FIRST)

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Abstract. Business Process Management (BPM) has emerged as a leading technology for business process solutions in current day enterprise systems. However, business processes do dynamically change as companies constantly evolve to meet their core business needs. Business processes involves a more complex socio-technical phenomenon where processes and people are the main components. In this paper, we propose an Interactive Framework for Immersive Research, Support and Training (I-FIRST) to assist Disadvantaged Business Enterprises' (DBEs) with an integrated business decision-support system. I-FIRST which uses a dynamic approach to model the planning and integration of business processes facilitates the alignment of DBEs' business processes to help them compete successfully. While the framework on one hand allows the ability to model the business processes to leverage expert domain knowledge, on the other hand, it immerses a decision-maker with selective modifications of some business processes using a dynamic feedback mechanism. The methodology proposed utilizes a complete end-to-end systems-based approach to leverage appropriate feedback and a computer-based learning environment called Teachable Agents (TAs) which focuses on the learning by teaching paradigm.

1 Introduction

Since the advent of affordable personal computers in the 1980's, the World Wide Web has become the most important driving force of today's businesses and the economy, in general. Companies have started to find a new business opportunity in a web-based environment. For example, companies such as Dell Computer Systems have revolutionized the PC market with their direct-to-customer approach to consumer marketing. Many companies have begun to realize that this approach allows them to achieve two of their most important, but often, contradictory goals, namely, maximizing profits and reducing retail costs, effectively and efficiently. In a traditional environment, these goals were very difficult for companies to achieve.

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However, by conducting their business through the web, more and more companies are beginning to stake out a claim in this market, with large conglomerates quickly adapting their business strategies to include the web as an enabling technology to conduct a low-cost business. This ability of transforming key business processes enabled by Internet technologies is termed as E-Commerce. The Internet has thus provided a greater access to useful information allowing customers to make informed choices. The removal of geographical trading barriers means that success will follow organizations that *(i)* offer the best deal, *(ii)* make it easy for other businesses and customers to trade with them, and, *(iii)* manage and leverage the advantages provided by E-commerce, while still adhering to their core business goals. Thus, to be effective, E-Commerce must be totally integrated into every business area of the organization that has a service, management or quality focus. Early pioneers have already been in the limelight for the past few years, and examples of new entrants into markets making tremendous inroads into well established competition galore. Moreover, those traditional companies without a stake in this market are struggling to keep up with the newcomers.

Therefore, the rise of E-Commerce has been the greatest threat from the Internet to most traditional companies. These companies are so tightly focused on their core business segments that they neither have the resources to develop business strategies for the new Internet environment, or they do not understand the implications of this emerging business environment. Many analysts have predicted that those organizations, which do not fully embrace a web-based business plan using E-commerce as an enabling and driving force, stand to lose enormously in the next decade when the Internet is still expected to grow at a rapid pace.

It is our perspective that with the rapid growth of consumer and business software applications, customers will require software systems to be distributed, interactive and intelligent (in a domain-specific sense), with ubiquitous human interfaces, and the ability to exhibit intelligent cooperative behaviors. According to Winograd, he states that “In the next fifty years, the increasing importance of designing spaces for human communication and interaction will lead to expansion in those aspects of computing that are focused on people, rather than machinery” [14]. We believe that E-Commerce software applications are not alien to such requirements and will need to adhere to similar objectives. While business to business (B2B) transactions will represent the largest revenue sector, revenue from customer-to-business (C2B) and business-to-customer (B2C) applications will also gain further attention. The PI believes that manufacturing companies that embrace the E-commerce strategy will be able to reduce inventories, increase productivity and profitability, cut costs and improve supplier relationships. Manufacturers will be able to procure products for the lowest costs from suppliers, thereby reducing the costs of procurement as well as growing their business without being dependent on specific suppliers. By incorporating a smart analysis module, one may even be able to optimize inventories by procuring supplies at an optimal price and time. Greater independence from suppliers may help boost the overall operating efficiency and productivity of manufacturing industries. E-commerce technologies can also replace traditional paper-based workflow in a manufacturing environment with faster, more

efficient and reliable communication mechanisms, thereby reducing redundancy and wastage of resources in various management activities such as report generation and information system integration.

Currently a vast equity divide exists between Prime Contractors and Disadvantaged Business Enterprises (DBEs) in several business enterprises, including within the domain of our interest, the highway and construction industry. Due to this equity divide, DBEs are falling well behind Prime Contractors in adequately competing and obtaining successful contracting opportunities. DBEs have become deficient in the knowledge and the leveraging of technology to map and implement appropriate business models and strategies in a timely manner to compete in an electronic marketplace that is being adopted by all organizations, including governmental organizations, such as the DOT. Through the use of emerging technologies for training and support, DBEs could be afforded the same technological advantages as Prime Contractors who utilize the appropriate business strategies to provide products and/or services to the highway construction marketplace in a timely manner. Without such timely utilization of emerging technologies to develop training and support mechanisms through the appropriate use of models for learning and teaching, DBEs will continue to be deficient in developing a profound understanding to compete successfully on highway projects. For example, a lack of the utilization of emerging technologies for training and support forces DBEs to interpret the business process model based only on his/her particular perspective and to make untimely, and often incongruous, decisions during the planning and construction stages of a project. In the case of the highway industry, DBEs should have the flexibility to design a plan that best suits the USDOT's requests. The knowledge that guides such a design of inquiry response is implicit and often in the mind of a domain expert, e.g., project consultant; and some such decisions are context based and cannot be anticipated at design time. The increasing interest in business process modeling as a tool for capturing requirements and graphically documenting the processes of an organization to be supported by the enterprise information systems are widely evident from the mainstream literature [6]. However, this complex social phenomenon is more complicated than the scope and features of the traditional methods used. There is significant evidence in literature on the difficulties in mapping process logic to process models [12].

Consequently, DBEs may not fully understand how to automate the coordination of business processes in a timely manner. Such technology specifications would appear ambiguous and would result in a combination of issues that lead to eventual failure as the project evolves and progress through the various construction stages. Industry studies have shown that 53% of the BPM efforts go into defining the process requirements, and the process modelers are typically business owners rather than domain experts [5]. We believe that without the support of an immersive environment, the complexity of mapping business processes and providing appropriate support and training can negatively impact DBEs. As a result, the equity divide will only widen between Prime Contractors and DBEs due to such "disconnects". Hence we propose this interactive framework to better integrate the

use of appropriate learning and training methods, and to support effective business process realignment.

The goal of this paper then, is to provide a simple framework through the use of a domain expert (project consultant) for business process remodeling with appropriate immersive support for decision-makers to address “difficult” business processes through a continuous feedback mechanism. This framework is a direct attempt to design and implement a useful tool for capturing successful business processes and subsequently providing targeted training and support to guide the refinement of business processes to positively impact the success of the business. The rest of the paper is structured as follows: Section 2 briefly describes the goals of the US DOT’s DBE program. Section 3 provides business processes characteristics and Section 4 outlines the methodology for the business process modeling. Section 5 presents the complete Interactive Framework for Immersive Research, Support and Training (I-FIRST) and the integration best practices from equity theory, teaching and learning theories to support DBEs.

2 US DOT Goals for DBEs

The US Department of Transportation's Disadvantaged Business Enterprise (DBE) is a federal program that is intended to ensure non-discrimination in the award and administration of US DOT-assisted contracts in the Department's highway, transit, airport, and highway safety financial assistance programs. The goals of the program are to remedy past and current discrimination against disadvantaged business enterprises, to ensure a "level playing field" in which DBEs can compete fairly for DOT-assisted contracts, improve the flexibility and efficiency of the DBE program, and reduce burdens on small businesses. DOT's Operating Administrations distribute substantial funds each year to finance construction projects initiated by state and local governments, and public transit and airport agencies [9]. This research attempts to support DBEs in being successful in the pursuit of these opportunities.

3 Business Processes Characteristics

In traditional enterprise information systems, workflow technology has been widely used to automate the synchronization of business processes. However, the study of enterprise information systems would reveal that the system cannot be performed completely and adequately unless conducted in the organizational and social context in which the envisioned system will have to operate and support business processes. Workflows represent the organizational flow of control and information from one processing entity to another [14], [16]. A business process (e.g., budget decision making or procurement) consists of a number of tasks, such as collecting and analyzing financial data [11], requesting an item from a procurement catalog, approving a request, and compiling a purchase order [8]. The individual tasks possess characteristics, such as being well thought-out, multiplicity, expectation, and

exigency, that impact the type and level of flexibility required to provide sufficient business support. Providing a workable balance between flexibility and control is indeed a challenge, especially if generic solutions are to be offered. Clearly, there are parts of the process which need to be strictly controlled through fully predefined models. Over the past few decades, businesses were misguided by the belief that IT alone will solve all their corporate woes, and consequently businesses overemphasized the role of IT while underestimating the importance of a clear understanding and critical analysis of their business processes [4].

Business processes are a sequence of activities with circumstances that regulates when these activities will be performed, and the amount of resources required to perform the activities. Also, the processes require data to flow between activities and have interaction with those services. Simply put, a process is a specific ordering of activities with clearly identified inputs and outputs that create business value. Whereas a system is a combination of interrelated elements, parts, methods, or procedures forming a complex unitary whole working together toward a common objective as shown in Figure 1 [1].

3.1 System Diagram

In Figure 1 [1], the system receives input variables such materials, information, energy, and/or organizational structure which are then control by a controller. The controller which could be technical, political, economical and/or environmental triggers that monitors and affects the operational conditions of the system. Both human-made and natural systems exhibit collective behaviors amongst individuals in which the controller seek some form of equilibrium. The mechanisms which are called actuators are agents such as human resources, computer resources, facilities/utilities and maintenance that act upon an environment. Subsequently, the system produces output variables such as products, information, resources and/or waste.

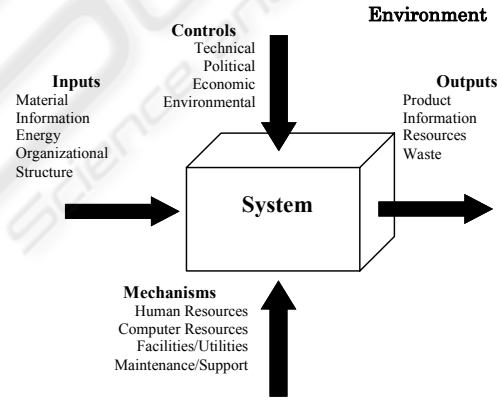

Fig. 1. System Diagram.

4 Proposed Methodology

Modeling any dynamic process still presents many significant challenges for DBEs. Modeling needs to be consistent and thorough in capturing relevant information so that DBEs and their employees can understand the business requirements that are captured in the model. During modeling, alternatives and exceptions to standard procedures must be captured, in addition to normal operations. Many professionals with differing interests and expertise have built process models to meet a wide range of business objectives. For example, a DBE may require a high-level view of a process to drive strategic decisions and to do process analysis upon receiving feedback, then implement the appropriate training needed for success. Lastly, utilizing feedbacks, DBEs would use the process model as the input to implement a solution. If we look at the control systems (or cybernetic) theory, it provides an explanation for our behaviors that can be described as goal-directed, or purposeful, as shown in Figure 2. At this high level of abstraction, it is applicable to business processes because it is guided by specific designs, tasks and business goals. One would find that the control system theory has been applied to the explanation of phenomena in a variety of fields, such as Physiology [2, 3], Engineering [14], and Psychology [10]. The basic idea behind the theory is that the behavior of a self-regulating system is effective and efficient only to the extent to which it successfully controls the end results of the behavior. In other words, it is important not only to produce a certain output in reaction to events in the environment, but also to monitor continuously the effects of that output and to adjust and subsequent behavior accordingly [14].

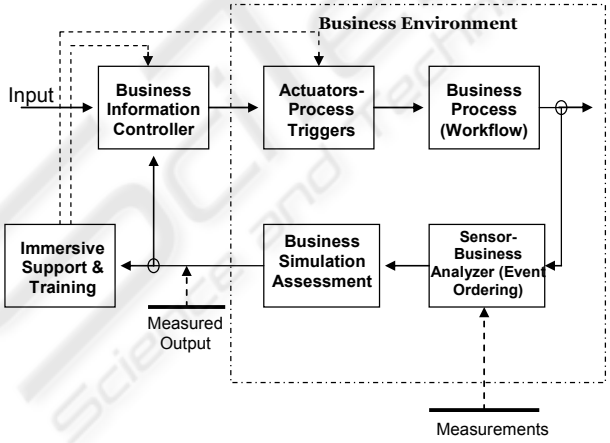

Fig. 2. The I-FIRST Model for Dynamic Business Support.

5 Modeling Framework

The following are the major steps in the I-FIRST framework, as captured in Figure 3:

1. The Project Analyst (e.g. Domain Expert) works with the DBEs (e.g. Project

Team) to get all of the information required to design the business model such as roles, tasks, sequence information, resources, data, narratives, requirements and so on using appropriate tools as input to construct the business process model.

2. The process model is defined by the Project Analyst (e.g. Domain Expert) working with the DBEs (e.g. Project Team) including the specifications for the modeling.
3. Next, the Project Analyst designs the feedback mechanisms required.
4. Both the specifications and the feedback are verified and checked for consistency.
5. Different simulation scenarios based upon historical event logs captured in a previous project of a similar nature, which in this research represent business strategies, are designed by a set of parameter values integrated into an extended Program Evaluation Review Technique (PERT) chart. This extended PERT chart not only captures the processes and their timelines, but also the resources *(including human personnel)* involved in the processes. Hence the traditional PERT representation is extended to include 3-part process representation such as {<resources involved >, <process or activity>, <time estimates>}. The following three time estimates are considered for each activity duration, ranging from an optimistic time to a pessimistic time, and a weighted average that is computed for each activity. Knowing the weighted average and variance for each activity allows the Project Analyst and the DBE to compute the probability of meeting different project durations dependent upon the availability of personnel and resources. The weighted average activity time is computed by the following formula: $t_e = (a + 4m + b)/6$, where t_e = weight average activity time, a = optimistic activity time, b = pessimistic activity time and m = most likely activity time
6. During the assessment stage, the results are analyzed using a total ordering of events scheme for the event logs, because it is possible that two events a and b that are not related by the happened-before relation (either directly or indirectly) may have the same timestamps associated with them. For instance, if event a and b happen respectively in processes P_1 and P_2, both events will have the same timestamp. Therefore, for total ordering on the set of all system events, an additional requirement is desirable: No two events ever occur at exactly the same time. Using this method, we will have a way to assign a unique timestamp to each event in the system to provide a total ordering for all events in the system.
7. Additionally, Key Performance Indicators (KPI) derived from the various process representations will be used as measures designed to track the critical success factors of a business. This monitoring capability allows the DBE to effectively monitor its KPIs. It also helps the Project Analyst (Domain Expert) identify the problems and bottlenecks in the existing processes, thereby closing the development loops within schedule. If the simulation results are not satisfactory, one would proceed to the stage which calls for reassessing the design and specifications.
8. Upon unsatisfactory simulation or assessment results, the assessment, design, model and specifications are re-evaluated.
9. If the simulations results are satisfactory, the process calls for the stopping of iteration.

10. Same as 8.
11. Upon re-evaluation the process is adapted to provide a refinement to address the drawbacks – This can be adding additional resources, reordering the occurrence of events so as to lead to better chance for success in completing the process, identifying appropriate training for some personnel, etc.
12. Critical information will be identified and appropriate sessions developed for employee training and support.
13. Selected employees will be reintegrated into the project team after successful completion of the training activities.
14. Project event logs from business process models are fed into controller where they will be engaged using a Teachable Agent. The computer-based learning environment called Teachable Agents (TAs) that focuses on the learning by teaching paradigm.
15. Upon the successful completion of the business process (workflow) and satisfactory assessment results which will lead to the next step (16) for the stoppage of iteration.

5.1 Evaluation

Upon utilizing this methodology and artifacts, it would require an appropriate evaluation of the soundness and rigorousness. According to Hevner et al. they suggest that graphical representation should be very simple, intuitive and easily understandable, at the same time, the accuracy and adequacy of such a representation should not be compromised [7]. Furthermore, Hevner et al. suggest that methods deploying artifacts should be evaluated using observational (e.g., case study) and experimental (e.g., simulation) methods. Observational (case study) approach reveals the applicability potential of a method and its artifacts in a given environment and category that are targeted by the method. For example, case studies on different size organizations, different levels of complexity, different levels of abstraction, but all within the same category, e.g., highway and construction oriented firms (architects, engineers, construction firms). Experimental (simulation) approach reveals if models can be checked, analyzed and verified. This approach which provides a business simulation assessment, not only allows models to be checked for reliability, but it eliminates syntactic errors, illustrates dynamic behavior of models, and lends to formal analysis. The business simulation assessments are team-based approach activities designed to provide change in the business management of the firm. The simulation assessments are used to enhance the project team understanding based on the various cultural styles and their personal impact on the business environment. The simulation prepares decision-makers for their role in aligning the business specifications and strategies with the technical framework that small businesses need to be successful. By enabling the decision-maker to immediately experience and participate in the simulated business process, they will continuously help keep the business and strategic views of the process aligned or "synchronized". The simulations are designed to offer the following (TIPS): *(i) Teach* project teams about the overall required business environment; *(ii) Improve* project teams problem-solving skills and decision-making effectiveness; *(iii) Promote* each project team

member's acceptance, and the readiness for change; *(iv) Strengthen* cooperation and communication in implementing change concepts.

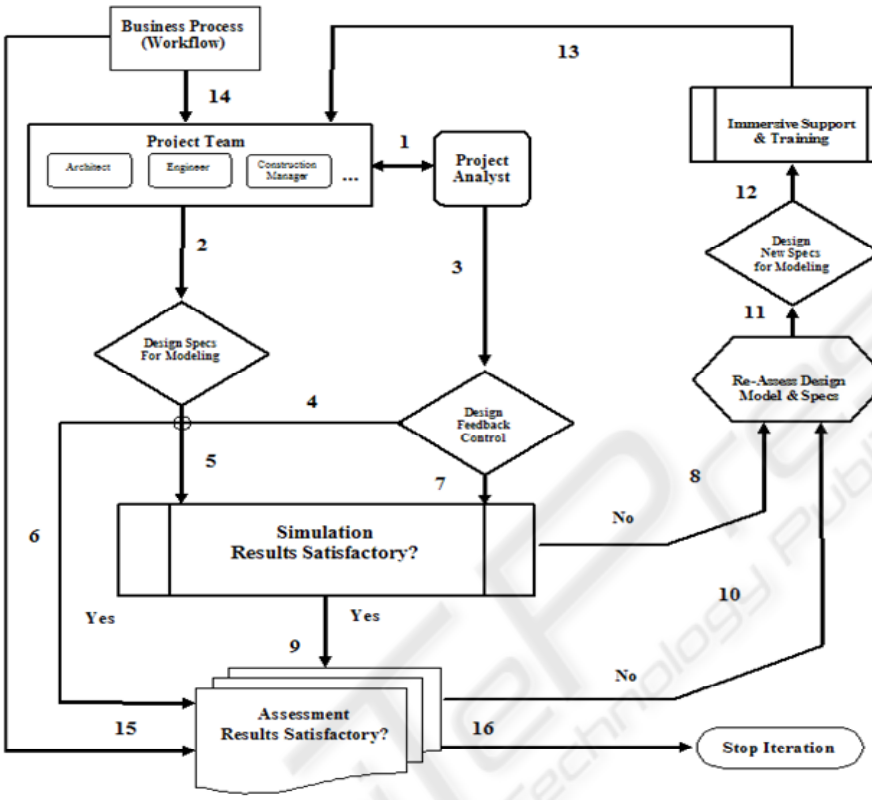

Fig. 3. Framework of I-FIRST Logic Approach.

6 Conclusion and Future Work

This paper provides a brief overview on the I-FIRST framework being developed for business process modeling to support DBEs. Since people learn in many ways such as seeing and hearing; reflecting and acting; reasoning logically and intuitively; memorizing and visualizing and drawing analogies and building mathematical models, this research is designed to support different dimensions of learning and training styles to provide businesses, specifically DBEs, a enhanced opportunity to be successful in the pursuit of external funding. Past research on the timing and content of feedback on individual immersive learning in computer-based learning environments has shown that directed or corrective feedback helps with immediate learning, whereas guided and metacognitive feedback help in gaining a profound understanding of the domain and developing the ability to transfer this knowledge.

As this work evolves in the immediate future, we plan to support the use of multiple learning models integrated with appropriate visualization to support the

faster aggregation of context-dependent information such as important concepts and specifications so that employees of a DBE can learn faster and compete with Prime contractors in the highway and construction industry. Key insights gained to help people in DBE enterprises include supporting discovery and self-explanation of important concepts through immersive training so that the decision-making skills of employees are appropriately augmented.

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