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The Disciplinary Nature of Business Engineering

Togar M. Simatupang
School of Business and Management, Bandung Institute of Technology, Bandung 40132, Indonesia.

Orcid: 0000-0002-6578-0998

Akbar Adhi Utama
School of Business and Management, Bandung Institute of Technology, Bandung 40132, Indonesia.

Orcid: 0000-0002-8625-038X

Nur Budi Mulyono
School of Business and Management, Bandung Institute of Technology, Bandung 40132, Indonesia.

Orcid: 0000-0001-6135-9357

Abstract

Business Engineering has evolved in importance within the firm and education. Although business engineering is now an established field, the distinction between business engineering and other engineering fields is relatively immature and requires further investigation. The body of knowledge of business engineering is also yet unclear. The purpose of this paper, therefore, is to clarify the distinction between business engineering and other engineering applications to business enterprises and to propose a preliminary body of knowledge of business engineering based on previous research. The idea of the framework is to employ engineering principles to design and improve a business entity by translating strategy into the integration of process, organization, and technology for creating sustainable competitive advantage.

Keywords: business engineering, body of knowledge, academic discipline

INTRODUCTION

Business engineering which is a multi-layered approach to business is of interest to both academics and practitioners [1]. The basic view of business engineering is to treat a business as an integrated system that can be developed to attain better performance [2]. Multi-dimensional frames, theories, and methodologies have been used in describing, modifying, and explaining a business system [3]. As a consequence, diverse views of business engineering make it difficult to conceptually promote this discipline in practice. The main motivation in exposing business engineering is then to eliminate confusion of its core constituents and to elaborate its distinct disciplinary identity.

Business engineering has been known as an academic field thought at higher education primarily in European countries. This field is relatively new and accepted as the interaction between business domains and engineering applications. The core includes the design of a business with analytics and supporting information tools in a systematic way [2]. There has been an increase in dialogue about the disciplinary nature of business engineering. The discussion has been sorrounding a distinctive feature of business engineering compared to other fields such as the general operations management (OM) field, supply chain management, and the latest developments in engineering management even with industrial engineering. This raises the issue of the more appropriate position to frame business engineering conceptually as a separate body of knowledge.

The field of business engineering has undergone significant development. The term was first coined to embrace the advantages of information technology for transforming a business system [3]. The conventional methods in the industrial era are no longer adequate to address a new level of spatial and participatory complexities [4]. The digitalization of enterprises becomes a common phenomenon in the information era. Business engineering is often regarded as a subfield of business informatics for the heavily use of information technology [4]. Business engineering is also viewed as a form of organization development to transform a business system to be more competitive [2]. The latest development extends business engineering to incorporate value chain engineering that spans a network of companies [5, 6, 7]. The development of business engineering indicates little agreement on the primary functions of business engineering.

This research asserts that the unclear disciplinary identity of business engineering is due to the parallel development and contributions from different broad fields based on their own methods and approaches. The previous contributions tend to improve the functional areas of business and not to develop a substantial body of knowledge [2 and 8]. Informatics becomes

a predominant approach to represent business engineering [4]. For example, informatics enables a business entity to be transparent and responsive in dealing with complexities and risks. This makes the current approach to business engineering overlooked a holistic view to the body of knowledge of business engineering.

This research, therefore, attempts to address the problematic issues surrounding the disciplinary identity of business engineering which is conducted in two stages. First, the search for the disciplinary identity of business engineering relative to other engineering applications to business enterprises is often the focus of ongoing debate. The proposed tool to resolve the debate is based on a binary aspect to developing the engineering applications according to two main dimensions: a strong emphasis in prescribing levels of business organizations ought to change, and a concentration on exploring predominant focus on engineering methods. This stage used a synthesis approach to differentiate positions of previous disciplinary fields of engineering approaches. Based on this conceptualization, the four engineering fields of business enterprise are able to be identified and the position of business engineering as a distinct disciplinary identity was clearly shown.

The second part of this research attempts to clarify regarding the meaning and scope of business engineering. A body of knowledge (BOK) framework needs to develop that builds on what has been carried out in the previous research. The objective is to extract commonality of the identity of business engineering across functions. Relevant literature in the field of business engineering was examined to critically appraise aims and existing knowledge and cast light to how to develop business engineering body of knowledge framework.

ENGINEERING APPROACHES TO BUSINESS ENTERPRISES

The basic question in business is how one can dramatically improve overall business performance. An engineering approach follows the creativity-based engineering design process which is known as the application of scientific knowledge to solving problems in the real world. Engineering based business development means the applications of engineering principles to the design, development, implementation, testing, and maintenance of business enterprise in a systematic way. Engineering approaches are the activities of research, design, testing, and operations of systems-level business and general computing methods. The engineering approach is directed to be able to identify all aspects of business mechanisms and explain how the establishment and use of basic engineering principles in order to economically ensure that a business system is reliable and works efficiently in a real situation.

The presence of engineering applications has moved the attention to both technical and social aspects of business enterprise and the concerns of an organization to focus on a particular state of change. The quest of engineering is about what objects (i.e., knowing what) to change and what methods (i.e., knowing how) to build. An object of change is an entity which has a unique identifier and a state consisting of a collection of attributes. The state of an object can only be modified, redesigned, and improved with a set of methods assigned on the object [9]. The matching between object and method determines typical engineering interventions that suggest improvements for structuring work design and organizational systems, implementing operational systems such as production and marketing processes, and creating required information, rewards, and control systems to ensure organizational efficiency and effectiveness. The nature of engineering approaches to business enterprises can thus roughly be divided in two dimensions: focusing on understanding what organizations undertake in different states of change and focusing on understanding typical orientations of engineering methods.

The first dimension is the states of change by which organizations move from their present state to some desired future state to increase an organization's ability to create value [10]. The change process is to try to answer the question of how one gets from here to there. The narration is often required to explain the underlying logic of the change that divides time into serial stages. The first step in managing change is to identify the type of changes. There are many issues to consider in identifying business change whether the changes are focused on processes or structures for creating value. The attention of change can therefore be divided into processual and structural states. Processual states are business procedures and processes of adding value to input factors by turning them into goods and services [11]. The changes include process reengineering, new product design, service development, and new technology adoption. Structural states are the concerns for an arrangement, pattern, architecture, and organization of interrelated elements in a business system which gives forms and stability.

Structural state usually involves recognizing the needs to redesign fundamental architectures of the way of doing business in a response to unexpected market changes that often results in a shift in work culture. There are two types of structure: (1) technical structure is technologically-related operations, infrastructure and functions such as information technology networks and systems that have an architecture, and (2) social structure is the organized set of social institutions and patterns of institutionalized relationships that together compose business. Examples of structural change include implementing major strategic and cultural changes, reshaping business strategy, adopting radically different technologies, making significant operating changes to meet new supply and demand, and reforming product and service offerings to meet unexpected competition and dramatic reductions in revenue.

The second dimension is the orientation of methods focusing on the design, construction and evaluation of methods, techniques, and support tools for business development. Engineering methods in business enterprise are related not only to the applications of engineering principles but also to the way of constructing new methods from the existing ones [12]. The orientation of methods offers technically oriented methods and socially oriented methods to include instruments, tools, and rules of improvements. Technically oriented methods have been proposed to follow hard engineering tools such as procedures, heuristics, algorithm, analytics, computation, and experimentation. For example, there are several methods for quality improvement with a technical orientation such as statistical process control, process mapping and flow charts, and failure mode and effect analysis. Socially oriented methods have focused on rules and social to attain successful change, not only individual actors but also concerted action to foster company performance. Improving business system is a social process so that theories and methods of social science can be used to engineer business practices.

Matching objects and methods results in a stylized way to expose the four disciplinary identities of engineering approaches to business enterprises is shown in Figure 1. In case of business development, there are four fields of engineering approaches characterized by interventions available for specific fits of states of change and orientation of methods: Industrial Engineering (techno-processual intervention), Engineering Management (socio-processual intervention), Enterprise Engineering (techno-structural intervention), and Business Engineering (socio-structural intervention). An intervention is a set of planned actions based on engineering methods to improve states of change intended to increase the effectiveness of organization. Each field serves as specific improvement interventions whereby methods are created to match specific organizational situations.

Matching objects to change and methods to build as engineering approaches to business enterprises		Orientation of methods	
		Technically Oriented Methods	Socially Oriented Methods
States of change	Structural States	**Enterprise Engineering** (techno-structural intervention)	**Business Engineering** (socio-structural intervention)
	Processual States	**Industrial Engineering** (techno-processual intervention)	**Engineering Management** (socio-processual intervention)

Figure 1: The four disciplinary identities of engineering applications to business enterprises

Industrial engineering is an engineering field that focuses on techno-processual intervention. According to the Institute of Industrial Engineers in USA, industrial engineering is "concerned with the design, improvement, and installation of integrated systems of people, material, equipment, information, and energy to make a product or provide a service." It can range from technically setting work standards, setting up production lines, introducing new techniques or approaches, developing processes, designing work, costing products, plant layout, and quality control. Although it primarily develops technical methods to build, industrial enginnering is not a thing-centric engineering such as civil and mechanical, but a people-oriented engineering which considers the mechanistic integration of men and machines, including human factors and ergonomics in workplace design. The emphasis is on designing, controlling, and optimizing processes in industrial systems and services using mathematical modeling, computer simulations, engineering economics analysis, work design, and quality engineering with a view to improving productivity, raising product and labor quality, and quantifying risks from a technological perspective. For example, industrial engineering suggests intervention to commerce logistics by developing technologies and systems that support physical logistics process related to electronic commerce and the Internet. Business Process Engineering is one of the typical techniques of industrial engineering as a radical redesign of business processes to achieve dramatic process improvements in cost, quality, service, and speed [13].

Engineering management is an engineering field that focuses on socio-processual intervention concerned with capitalizing on the applications of engineering principles to support management responsibilities. It is different from ordinary management because this field is characterized by both the applications of engineering principles and the organization of people, technology, and projects [14]. IEEE Transactions on Engineering Management endorses that engineering management [14] is "the discipline addressed to making and implementing decisions for strategic and operational leadership in current and emerging technologies and their impacts on inter-related systems." This field relates to making strategic decisions with financial analysis tools, making management recommendations with operations research methods, learning more about costing and cost analysis, managing engineering design, planning production activity, and managing quality programs. The emphasis is on the functioning and the management of innovative organizations and projects. Engineering management is also a set of procedures required to develop and implement various management systems such as ISO 9000 Quality Management System, ISO 14000 Environment Management System, and ISO 28000 Supply Chain Security.

Enterprise engineering is an engineering field that focuses on techno-structural intervention that attempt to engage the complex architectural determinants of enterprise as a way of influencing better effectiveness [15 and 16]. An enterprise is a

socio-technical system consisting of interdependent resources of human, information, and technology that often interact with each other and their environment. According to the Society for Enterprise Engineering (SEE), enterprise engineering is defined as "a body of knowledge, principles, and practices having to do with the analysis, design, implementation, and operation of the enterprise". Enterprise engineering geared toward the rapid design and development of complex organizations to eliminate disconnects between and among departments and develop the cross-departmental activities that made up end-to-end business processes that deliver value to customers. It combines two important methods of organizational science and information engineering to develop theories and formal methodologies for the analysis, design, and implementation of enterprises. Formal methodologis and techniques such as Computer Integrated Manufacturing Open Systems Architecture (CIMOSA), Unified Enterprise Modeling Language (UEML), Enterprise Function Diagrams (EFD), and Petri Nets have been developed to analyse, design, and test business solutions [16, 17, 18]. Other approaches to enterprise engineering include Enterprise Architecture (EA) employed to analyse, design, plan, and implement information, process, and technology changes in order to translate business vision and strategy into effective enterprise [9, 19, 20]. The various aspects of an enterprise are used to identify, modify, and visualize required changes based on enterprise architecture frameworks such as Enterprise Architect, ARIS (Architecture of Integrated Information Systems), TOGAF (the Open Group Architecture Framework), Zachman Framework, and Service-oriented modeling framework (SOMF).

Business engineering is an engineering field that focuses on socio-structural intervention through conceptualization, modeling, analysis, organization, calculation, and the design of complex organizations. van Meel and Sol (1996) define business engineering [21] as “an integral design of organizational architectures and information systems.” Business engineering is concerned with the design and implementation of business solutions that incorporate business model, business processes, organizational structure, information systems, and information technology. It assumes organizations as a structure of socio and cyber actors that undertake business activities. The importance of social structure is explored by comparing existing archetypes of business systems through a methodological application. Socio-structural intervensions include decision right allocation, policy, administrative structure, rule, and hierarchical organization. Approaches to business engineering relate to the usage of business architecture as specific methods to describe, depict, and improve business performance. The examples of business architecture frameworks are ARIS (Architecture of Integrated Information Systems), Business Engineering St. Gallen, and the Open Group Architecture Framework (TOGAF).

BUSINESS ENGINEERING FOUNDATIONS

The technical and economical aspects of business transformations are far more complex to be created intituitively by individuals. To exploit business potential of IT innovation, it needs to collaboratively assess and implement technologies, strategies, processes, and information systems [3]. Business engineering is a composite discipline that combines components from general management, technology management, information systems, and organizational psychology into a method or model based on engineering approach to corporate transformation. Business engineering is the results of applying basic principles of engineering disciplines into business transformation based on apporiate methods and models or new company creation that exploits business potential of IT innovation. Business engineering is the design discipline for companies of the information age. Its primary theoretical foundation is method engineering [12].

The introduction of information technology into business has changed the way company operate their business from manual into automated process. This change impacts to business engineering which focuses on combination between business management and information technology. According to Chao (2016), e-business engineering has evolved from the aforementioned areas of business engineering and e-business, which also involve the study of computer science and management science [22]. The main goal of business engineering is to satisfy the demand of client and to make enterprise profitable using the advantage of new information and communication technology.

Business engineering provides methodological supports when it comes to business transformation induced by information technology [4 and 23]. Luczak et al. (2003) describe a methodology that delivers a first approach for the integrated planning of services and ICTs with systematic development of electronic business and e-business engineering [24]. These methodologies use the basic idea of engineering science in systematic way and called e-business engineering. Janssen et al. (2003) define e-business engineering should consider the differences specific to e-business in order to reduce the risk of project failure and not to forget the lessons learned from business process engineering [25]. Otto et al. (2015) proposed digital business engineering as a comprehensive method for digital business model design [26].

Thomas et al. (2006) describe business engineering as a field emerged to enrich existing the development of information system with focus on strategy and process design [27]. In today’s prespective, this can be understood as the method and model-based design for business. By using method in business engineering, businesses were to be redisigned and take advantage of potentials in information technology from the bottom up with the help of engineering principles. Thomas et al. (2006) state that a business process has established as the organizational object of the design [27]. The business process design and the analysis with the IT support are important for

business engineering. A business process design must follow a comprehensive approach which encompasses the planning and control, as well as the management of operational workflows. Scheer and Nüttgens (2002) states that business processes have emerged as the focal point of business reengineering [28]. The Architecture of Information Systems (ARIS) can be used as a keystone for Business Process Reengineering and Business Process Management. ARIS-House of business engineering (HOBE) enhances the ARIS process architecture by addressing comprehensive business process management, not only from an organizational, but also from an IT perspective.

The transition to the networked company signifies a massive innovative leap at the levels of business strategy, process, and information system. Business engineering [2 and 4] is a method based approach to transformation. Business engineering has the goal of incorporating the transition to the networked enterprise within the business strategy, as well as implementing this strategy within processes and providing it with information system supports. den Hengst and de Verde (2004) use collaborative business engineering approach and simulation modelling suport to understand the insight of Business Process Reengineering [8]. The collaborative business engineering approach aims to understand the key reasons for the failure rate of Business Process Engineering. Simulation techniques are used to gain dynamic insight in existing and future business processes and their quantitative metrics.

BUSINESS ENGINEERING APPROACH

As one of the pioneers in the business engineering approach, the ARIS concept distinguishes between views and levels of description. The views of description consists of organizational, data, functional and control of processes while the level of description is an interdependent structural part of views that comprises of process engineering, process planning and control, workflow control, and application systems [28]. The four levels are interdependently connected to achieve greatest efficiency possible in terms of business organizational solutions. ARIS represents business process in diagrammatic fashion so as to provide unambiguous starting points for the development of information systems.

Business engineering is viewed as a system and therefore has structural and behavioral aspects. Semantic Object Model (SOM), for instance, differentiates three layers of systems: the strategic business plan, the operational business process models, as well as the specifications for implementing application [29]. The strategic business plan defines the business system from an outside perspective in terms of its goals, objectives, and strategies embedded in a broader socio-cultural context. From an inside perspective, the business process model implements the enterprise plan with the resources (organization, information system, facilities) from specification layers.

Business engineering approach of St. Gallen distinguishes design level strategies, organization, and information systems to reduce complexity of the transformation process. With the goal of transformation, scientific innovation, and business success, St. Gallen approach to business engineering has been applied in many consultancy projects and received support from renowned software tools such as the ARIS. Business engineering approach in St. Gallen distinguishes three design levels of enterprise: strategy, process, and system. The strategy consists of business model comprising the mid-term to long-term development and the positioning on the marketplace, while the process level and the system levels comprise of organizational model and information system architecture, respectively. Two design level areas were defined to complement the approach. They are cultural and human aspect, and transformation and control for structuring transformation of enterprises and coordination among network participants.

Winter (2001) proposes transformation model of enterprise enabled by IT innovation in which guidance is provided to re-create existing companies [3]. Some of IT Innovation make significant transformation such as cheap communication networks, connected smart appliances, growth of microprocessor, digital convergence of traditional media, and flexible networking between individuals, organizations, and digital devices. The business engineering results from applying basic principles of engineering disciplines to business transformation based IT innovation. The main components of transformation include business knowhow, strategic thinking, business design and change management, and business architecture. As a discipline, an additional task of business engineering is to take part in the design of the business focusing on the business strategy, business process, and information systems. Business engineering approach is based on a vision of networked business architectures of the information age, a model based approach to redesign the organization, and a set of methods developed in the context of research in information systems, business administration, and organizational psychology.

According to Hong Kong Institute of Business Engineers, there is still lack of recognized professional designation in business engineering. Unlike other professional disciplines, such as accounting, finance, law, and engineering, business engineering has not yet had its professional designations to embrace its explicit professional frameworks, guidelines, well-defined requirements of capabilities, and effective means of assessment. To solve the issues of “management professionalism”, business engineering concept was established with the offer of providing optimal solutions to risk monitoring, analyzing, planning, implementing, and communication. The approach comprises of incorporating education, learning, and application of theories; learning assistance; formulation of a set of objective management standards in components, logics, and mechanism; abolishing the inconsistency in management theories and practices; and

discerning between management "fads" and management's core "principles".

Designing a business architecture function in business engineering is not an easy task. Most of the prominent business architecture frameworks lacks of specificity, and is not tailored to the specific management understanding of the specific enterprise [30]. The Open Group Architecture Framework (TOGAF) presents a structure of organizational architectures that is considered by practitioners as an interesting framework for architecture management. It offers a holistic approach in designing, planning, implementing and maintaining information architectures that cover an important requirement of business engineering. The enterprise architecture in TOGAF is modeled into domains of business architecture, information systems architecture, and technology architecture. The framework of TOGAF covers some important features such as modular structures, content frameworks, extended guidance, and architectural styles.

A complement of TOGAF that is specially designed for relatively large enterprise, the 3rd gears' Business engineering system, is designed to be effective and relatively easy to implement for small to medium-sized businesses due to the SME specific design of its improvement processes and software applications. It involves the use of a specialized software platform that integrates key business structures and operational performance processes. The 3rd gear system encapsulates the key areas of strategy, business process, technology and people. Combined with its ease of use for business owners and managers, the four principles of the 3rd gear system (holistic, measurable, duplicable, and permanent) have made the 3rd gear model popular within the SME market place.

Business engineering concepts have been taught in many higher worldwide educational institutions. Most of them open a course of business engineering in post graduate level with the unique concept and approach of business engineering. The examples of the universities include Solvay Brussels School of Economics and Management and the ICHEC Brussels Management School (Belgium), the University of St. Gallen (Switzerland), University of Oulu (Findland), Instituto Tecnológico Autónomo de México (Mexico), Steinbeis University (Germany), ESB Business School, Reutlingen University (Germany), University of Chile, University of the Pacific (Peru), Escuela Superior de Economia y Negocios (ESEN) (El Salvador), Ateneo de Naga University (Philippines), National University of Engineering (Nicaragua), and Universiti Malaysia Pahang (Malaysia).

In case of handling enterprise challenge with business engineering, there are four approaches characterized by both focus of the enterprise and enabler of changes. Many approaches that had been proposed by academicians and practitioners can be summarized in Figure 2 to identify business engineering approaches. All approaches have a similar tendency in characterizing business engineering in structural states.

Enabler / Focus	Information Technology	Enterprise Management
Integration	ARIS	SOM, TOGAF, 3rd Gear BE
Transformation	St. Gallen	Hong Kong BE Institute

Figure 2: Business engineering approaches

BODY OF KNOWLEDGE FRAMEWORK

As a discipline, business engineering has a world view that guides its development in practice and education. In the business engineering paradigm, a business is viewed as a complex system of structures and processes that can be engineered to leverage business performance. Business engineering applies engineering principles of problem solving, analytics, and systematics in transforming a business system.

Most previous research contributing to the body of work surrounding business engineering takes the position that ITC (information and communications technology) has dramatically altered the role of information in the business. Information technology has practically enabled the required coordination among different actors in the business to analyze and solve business problems from an analytical point of view [31]. Business organizations often adopt the advancements of information technology to benefit fully from efficient and timely information sharing and new ways to produce and market products and services [32]. Business engineering development has been driven by the imperative to increase value-added processes of the entire organization, not just that of an individual division. The fundamental principles of business engineering can be recognized from the requirement of systems integration theory in order to integrate all elements of the business. Information technology serves as the prime driving force to create seamless integration of an organization's systems with suppliers' and distributors' systems with a focus on serving the needs of end consumers [2, 31, 32].

The increasing adoption of information technology is not only to revolutionize organizations to create value, but also has tended to heighten requirements for process improvements and innovations. Business engineering becomes important to keep improving business performance by optimizing the efficiency of integrating value added activities in the provision of a product or service. It uses tools such as computer simulations and modeling complemented with social theories and methods to gain a deep understanding of how a business system can be changed to be more productive. The domain of business engineering includes a profound understanding of how strategy function, how business processes should be designed, how business activities can be optimally organized, and how

business and innovation processes work. Systems analysis can use applications to find leverage points which are objects within a business system where a small shift in one thing can produce big changes in productivity.

Business engineering suggests a structured development process that proceeds from requirement, conception, architecture, prototype, and operation. The starting point often begins with devising strategy, identifying business requirements, designing operation and information systems to meet predetermined requirements with the aid of quantitative methods and models. Leverage points are primarily through the design of strategy, processes, business organization, and technology. In the implementation phase, business engineering is concerned with the development of management control systems to aid financial planning and cost analysis and the design of planning and control systems to coordinate activities and guarantee product or service quality. Furthermore, business engineering also develops value chain aspects of a business including procurement system, the physical distribution of goods and services, and plant locations.

The framework of body of knowledge attempts to be comprehensive and as inclusive as possible in elaborating both engineering tasks and leverage points that represent processes, people and organization, and the networks of organizations. The St. Gallen approach to business engineering, for instance, consists of comprises fundamentals and methods for different kinds of transformation projects. The complexity of the transformation can be reduced by cascading different design levels of strategies, organization, and information systems within the transformation process. The leverage points of strategy can be identified as capabilities and resources, business segments, customer access, competitive position, ecosystem, and revenue and cost structures. Meanwhile, the leverage points of organization might be in the forms of organization and operational structures, business processes with accompanying process performances, procedures, and tasks. Finally, the leverage points of information system include applications and technical services, software and data, and IT infrastructure.

This preliminary study proposes that the framework of body of knowledge can be divided into broad categories to incorporate engineering assignments and leverage points. Engineering assignments is spanned from requirement, design, prototype, testing, operation, and maintenance. The leverage points include strategy, processes, information, organization and people, and technology. In addition, engineering assignments and leverage points are accompanied by activity systems, monitoring, and controls to ensure quality of deliverables.

DISCUSSION

This paper proposes a stylized classification of engineering approaches to business enterprise based on objects and methods. Objects of interest becomes easy to be identified and clarified in terms of substantial knowledge and requirements. In the previous research, the engineering objects are often observed and designed based on the static information which tends to generate the human error because lack of feedback and unclear requirements. The classification informs the possibility of examining smart objects that can be verified and designed in such a way to allow measurements for data collection, the use of analytics and computation, and the provision of reporting system. As a result, the smart object can be analyzed and built for both structural and processual states which incorporate analytics, computation, and intelligence.

The nature of business engineering exhibits the uniqueness of socio-structural approach to business enterprise. Business engineering suggests a structural analysis of the business and does not focus on functional management. The structural level of business engineering describes the architectural aspect on which the company should analyze and address different design layers within the company. Most of the current approaches agree to put the strategic layer consisting of strategic direction and values at the beginning of business design and analysis. Strategic layer itself would not bring significant contribution to the success of business unless excellent business process is established and controlled by human actors based on accurate and up to date information.

The necessity of information and its supporting technology is undeniable in the era of high competition. The infrastructure of Information technology becomes a foundation that supports all aspects of business processes and strategic intent. As the technological changes have influenced business environment in recent years, information technology (IT) has brought the greatest impact to business practices. This trend would continue at least until the end of the first half of the century when other major technological breakthroughs in the area of business engineering may provide entirely new ways of doing business as well as engineering function.

The way businesses manage a change and how successful they are at it, depends largely on the strategy, business model and process, technology infrastructure, nature of business, the change and the people involved. It is also dependent on how well the organization and people understand the need for the change and the process involved. Applying change management activities in business engineering can be instrumental in realizing goals for planned and unplanned changes, diagnose problems associated with the transition, and manage integration of enterprise management layers of strategic, business process, and technology infrastructure.

Business engineering is a ubiquitous concept in education sector which used to enhance engineering approach to business. The Conceive-Design-Implement-Operate (CDIO) approach can be adopted as a reference for business engineering education to create more interactive and collaborative learning environment for students and lecturers [33]. It serves a basis for the curriculum design process, and together with multimedia technologies and games it would become future learning trends in business engineering education. Further works would be

beneficial to search for learning tools and learning systems for different business contexts.

CONCLUSIONS

Engineering approaches to business enterprise is a unique improvement intervention to solve complex problems and implement solutions in practical and cost effective ways. Engineering works from detecting problems, working through various abstract ideas and concepts, and translating them into reality to attain specific business objectives. The ambiguity of different engineering approaches in the ongoing debate can be resolved as proposed in this research by synthesizing two dimensions of objects and methods in which the construction of methods are tuned to specific situations of engineering objects. It can be described as the creation of a new configuration to bring together four field of engineering to have distinct identities. The four engineering fields are industrial engineering, engineering management, enterprise engineering, and business engineering.

The proposed configuration can be used to eliminate confusion in the academic world such as the difference between enterprise engineering and business engineering that looks similar. By studying main characteristics of each field, it is able to produce a general comparison of these four fields of engineering. In addition, as a distinct disciplinary identity, business engineering then can be examined to construct a framework of body of knowledge.

Business engineering emphasizes the adoption of system approaches, problem solving techniques to design and implement effective and productive processes that combine people, organization structure, and technology. The body of knowledge framework aims to show engineering assignments and leverage points in combination with problem solving, technical skills, and knowledge related to business engineering that can clearly expose how business engineering designs and improves technologically oriented services or companies. The framework of body of knowledge offers a distinct identity used to maximize benefits of the applications of business engineering.

The main contribution of this paper is the development of a classification configuration of the four fields of engineering approches to business enterprises. Two relevant dimensions of states of change and orientation of methods are used to compare and highlight distinctive features of the four disciplinary fields. The paper also identifies preliminary framework of body of knowledge for business engineering.

There is some further research around the kernel of business engineering which needs to be conducted. The future research includes the verification of the classification configuration to show detailed features of the four fields, the inclusion of business models, reference models, tool supports for modeling and reporting, and consideration of business application systems. In addition, the laddering technique can be applied to test the proposed business engineering body of knowledge. This technique is used to identify means-end chains of sets of knowledge and tools [34 and 35].

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