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The Case for the Business Process Engineer

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The Case for the Business Process Engineer

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Abstract

Structuring the operation of businesses by process-based constructs with a concurrent emphasis on the term engineering has become a truism although the effectiveness of applying these ideas has been mixed. This paper concludes that an obstacle to business process (re)engineering is the lack of a business process engineer role with an associated professional education, standards, and community. This conclusion derives from an analysis of natural knowledge domains in system design, comparison with existing engineering practices and the characteristics of business systems.

We observe that:
1. There is an increasingly critical need to master the subject of business process engineering for an individual firm as well as the general U.S. industry.
2. At present there does not exist a profession of business process engineers. Their role in a firm is filled, on an ad-hoc basis, by business line personnel, information technology analysts or architects, and/or management consultants.
3. These other professionals, while having their own specialized skills valuable to a firm, do not necessarily have the optimal skill set for business process engineering.
4. We therefore conclude that there is an urgent need for a professional business process engineer. We discuss the skills required of this profession and propose that academic institutions should seriously consider such a new program today.

1. Introduction

It would be reasonable to assume that business process redesign or reengineering (BPR), an area much talked about by industry and academia alike and supposedly practiced by a wide gamut of industries for a decade or so, is a fairly well defined academic/professional discipline. Our careful examination of this area indicates that this is not the case. In this paper, we argue for the need of such a discipline practiced by a business process engineer (BPE). The success of the

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profession and, ultimately the business enterprises it serves, depends on associated professional community, education, and standards.

Valuable products and services efficiently and effectively delivered to a customer is the goal of every profitable enterprise. Since the industrial revolution regular cycles of technological innovation followed by periods of restructuring have moved from basic production, transporting goods to remote markets, to managing national or international scale corporations (Perez 2002). Over the last two to three decades, the focus of innovation has shifted from task-oriented productivity to responsiveness. In the eighties, enterprises recognized time as a competitive differentiator (see e.g., Blackburn 1990). The time to market of a concept or the response time to the customer became more important than cost. In the present cycle, technological innovation in digital processing and communication within an enterprise, between enterprises, between enterprises and consumers, and between consumers drive increasing velocity to market ever more so than before.

Digital processing has recapitulated the evolution since the industrial revolution. The first wave of computerization focused on factory automation. To a large extent, it failed to deliver the expected cost saving. Postmortem studies revealed that automation addressed only about 5% of the total time spent by an order in the factory. The real problem, the 95% spent waiting, directed attention to the process of converting an order to a product. The attention led to significant innovation in manufacturing process and supply chain management outside the basic, physical production scope. With cross-functional, business processes (see e.g., Davenport and Short 1990) came the realization that a set of related tasks in different functional areas - e.g., sales, purchasing, design, manufacturing, and distribution - had to be treated collectively. The focus, again was placed on automating activities, but this time across functional areas, within large “turn key” ERP systems. Similar results occurred for similar reasons (Davenport 1998).

The failure of the second wave of computerization in fact is not dissimilar to that of the first wave of factory automation. We believe that advancements in information technology (IT), in addition to automating routine business tasks and providing instant access to data and information needed, will also continue to transform certain businesses and create new business opportunities. However, we cannot expect IT to compensate for the inadequacies of a business process design. Automating an unproductive task will consume unnecessary resources even faster. On the other hand, automating a well designed process will provide additional yet critical benefits of time as a competitive weapon. When time delays cannot be eliminated or reduced through process design (such as in a step of physically transforming materials), automation is our only other resort.

In this paper we observe that the sequence of activities in business process design and engineering is analogous to that of a manufacturing process design. We elaborate this comparison in Section 4. Such similarity leads us to argue the need for a business process engineer as a more general version of the more familiar manufacturing systems engineer or process planner. This new role does not replace the typical multi-disciplinary team that is assigned the responsibility of designing a business process, but rather adds critical skills to the team so that the resulting process design is technically sound. We describe the role of the business process engineer in more detail in Section 5 and propose in Section 6 the core skill set a BPE ought to possess. In our concluding remarks in Section 7, we explain why it is important to recognize the need for the role of BPE and devote adequate resources for the creation of such at the present time. The time to act is now.

2. Definitions and Background

There are several definitions and interpretations of terms related to business processes. In this section, we present sample definitions of key terms as found in the literature, and establish working definitions that we will use in this article.

Process

"Any activity or group of activities that takes an input, adds value to it and provides an output to an internal or external customer. Processes use an organization's resources to provide definitive results on behalf of the business." (Towill 1997a)

Our definition of a process agrees in principle with the above. However, we wish to emphasize the ordering present within a group of activities by qualifying "activities" above with "activities arranged or linked in a specified order." The activities of a process are not just a set, but a set with very specific relations between the elements. We also note the often neglected role of resources in defining both the structure of a process and interactions between processes. The value of processes is not just in aggregating the functional activities but in coordinating actions and resources.

Business Process

"A linked or natural group of skills and competencies which start from a set of customer requirements and deliver a total product or service." (Towill 1997a)

"A set of logically related tasks performed to achieve a defined business outcome." (Davenport and Short 1990)

In general, we use a variation of the above definitions and add examples of the groups of activities, which allows us to use a narrower definition for this article:

A set of logically related activities in the day-to-day operation of a business, including planning activities (e.g., resource planning), manufacturing activities (e.g., building a gadget), business transactional activities (e.g., purchasing raw materials and selling products), and customer support activities (e.g., handling warranty issues).

However, in this article, we use the term business process to mean non-manufacturing activities, to distinguish from manufacturing activities for convenience of comparison. We also use "activities" instead of "tasks". As is customary, an activity is defined as a collection of closely related tasks and is therefore a level above a task in the process hierarchy.

Business Process Redesign/Reengineering (BPR)

"The means by which an organization can achieve radical change in performance as measured by cost, delivery time, service and quality via the application of the systems approach which focuses on a business as a set of customer-related core business processes rather than as a set of organizational functions." (Towill 1997a)

"The analysis and design of work flows and processes within and between organizations." (Davenport and Short 1990)

"… the fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service and speed." (Hammer's definition from MacIntosh 1997)

"… the redesign of an organization's business processes to make them more efficient." (Curtis et al. 1992)

BPR is seen by some as a tool or technique that has transformed organizations to the "degree that Taylorism once did (Davenport and Short 1990)." BPR has been differentiated from the constant tweaking of process details (a.k.a. continuous process improvement or CPI) by the "radical" or step changes that it causes in an enterprise's processes. In addition, cross-functional processes and the advancements in IT are often associated with BPR activities.

Our focus in this paper is on business process design/engineering and we believe that our definition and approach can easily be adapted to a redesign/reengineering situations by making the obvious changes. Like Towill (1997a, b) we also advocate a systems approach, wherein the focus is on the behavior and performance of the total enterprise.

Business Systems Engineering (BSE)

"BSE is a systems approach to designing new business processes and redesigning existing business processes. It provides a structured way of maximizing both customer value and the performance of the individual business." (Towill 1997a)

Business Process Engineer (BPE)

Towill's (1997a, b) work certainly help lay a foundation for our thesis here. We argue in this paper that there is a need for a professional role in the framework of BSE as defined by Towill (1997a, b). This professional role, whom we call a Business Process Engineer, would be a key contributor in the multi-disciplinary team that Towill advocated. As we will see in the later sections of this paper, the BPE draws on the principles of systems thinking with skills from a set of different yet related disciplines of business, industrial engineering, operations research, computer science, and information systems and technology. It is a professional discipline whose purpose is the design and development of business processes.

A number of authors have alluded to the importance of business process engineering recently. Karmarkar (2004) proposes several key competencies for a business enterprise to compete in the services based economy, one of which is business process design. In Chesbrough (2004), the author puts forth an agenda for services innovation research and argues, "Any useful understanding of the opportunities and risks that are unique to services innovation will invariably involve business process modeling, business models, systems integration and design." As we shall see later, these activities constitute a key set of components of business process engineering. Rouse (2004) proposes that industrial engineers need to expand their focus to the entire business enterprise and even external entities that interact with it, including its suppliers and distributors, customers, and competitors. The author points out a number of potential education and research topics, a crucial one of which is understanding the relationships between these entities and the entire value stream that flows within and between these entities. These relationships are manifested on a day-to-day basis in intra- and inter-enterprise business processes that need to be designed and controlled in an optimal way. Our paper contributes along the same line of thought as these works, but we show in detail why there is a need for business process engineering and specify what role a business process engineer would play in the overall design and operation of an enterprise.

A closely related work is Tien and Berg (2003), in which the authors propose a set of engineering methods and principles for service systems. These methods span the entire life cycle of a service transaction, from planning to execution to measurement. Our proposed role of the business process engineer would be a practitioner of some of these methods to design and engineer a business process. In particular, all of the four major characteristics of a service system (information driven, customer centric, e-oriented, and productivity focused) would be key foci of the business process engineer. Business process engineering would be a part of service systems engineering, but is not limited to service enterprises. It is applicable and useful for traditional manufacturing industries as well as government.

In the last several years there has been a fairly wide recognition in academia of the need of a transformation in business related academic programs to reflect the needs of the changing environment. Most notable are proposals in Industrial Engineering (e.g. Askin et al. 2004; Kamath and Mize 2003; McGinnis 2002; Rouse 2004; Settles 2003) and Business (e.g. Smith and Fingar (2002), Appendix E). Our paper here is a contribution to the requirements on these new programs.

Obviously, business processes have been in existence as long as businesses themselves. It is a necessity for a business to operate and deliver its output, be it a physical product or a service. It is only relatively recently (about 15-20 years ago) that we have used the term "business processes" and have focused on studying them. The reason is that up until then business processes were relatively simple and to a large extent manual. There was only one or two ways of doing things. Manufacturing processes, on the other hand, were already quite complex and required several engineering disciplines to set up production (most often including electrical engineering, mechanical engineering, and industrial or production engineering)[4]. Today, business processes have also become quite complicated due to several reasons. First, as physical products become increasingly complex, the complexity of supporting and coordinating all the production related functions has also grown accordingly. Second, logistics, be it material supply, distribution of products, or even collection of information from suppliers, customers, and end users have become a round-the-clock, global operation. All associated processes are therefore global in scope. Third, new technology has raised new possibilities and alternatives. For example, a customer can now place an order through different means: phone, email, fax, electronic data interchange of the world-wide web. The order management process has to handle all of these alternatives. Finally, the combination of the above three factors has increased the complexity and alternative possibilities of business processes that they now rival manufacturing processes. Coupled with the tremendous growth of the service industries where business processes are the manufacturing processes, it is natural to seriously consider the subject of business process engineering now.

3. A Framework for System Design

In order to expose the nature of the proposed BPE role we start from an articulation of the general problem of system design shown in Figure 3.1. This framework forms the basis for analysis of existing roles in business design and comparison with analogous domains. Referring to Figure 3.1, three horizontal layers appear in business design, corresponding to the design of the system as a whole, design of a configuration of components, and design of the components themselves.

The "system definition" layer (i.e., the top layer) defines the intent of the system, its positioning within a known external environment, and external behavior of the system in interacting with its

[4] There are many obvious examples of fairly complicated products that have been in large-scale production since World War II. They include consumer products such as automobiles and televisions, not to mention commercial aircraft and shipbuilding.

environment. Because the system is a part of its environment, these will be defined in the terms of the environment. The outcome of this band is a description of the external interactions of the system defining its relationships with the environment from the perspective of the environment (such as a customer). The external environment involved is generally very different in nature from the internals of the business system. Engineering the top band obviously requires strategic considerations of the environment that are only possible with distinct training, skills, and knowledge.

The "implementation" or component layer (i.e., the bottom layer) focuses on the design of each of a set of parts from which the systems is assembled. The view of each component is taken as part of the execution infrastructure, so the design takes place from the perspective of that infrastructure. Each component ultimately will represent a physical entity (such as a human operator trained in some specific tasks, a machine for producing physical parts, or a database engine), since a business will deliver some physical entity or activity to a customer.

In typical business process engineering exercises, the top and bottom layers are outside of the control of the design effort. The top band is clearly the job of senior executives or entrepreneurs whose "algorithms" are very much an entire research subject. Although the bottom band is usually not explicitly given (unlike the top band) at the outset of a business process engineering project, it is practically constrained to a finite set of choices, such as machine types, software packages, or traditional job descriptions or functional positions (for humans). It is entirely possible that new machines or software packages can be custom built, but such cases are not common. It would be technically easier to create new job descriptions, but would still be nontrivial to ensure acceptance and success of the new position. (We are creating a new job description in this paper.) As a result, in most cases the top and bottom bands are outside of the direct control of the design team.

If the external system environment were the same as the component implementation environment, the system design emerging from the system definition band would be immediately decomposable through the composition band into the specifications needed for component implementation. However, this is generally not true. As alluded to earlier, the system environment is defined by the requirements posed to the system from the outside, which are independently developed from the system composition and have no relationship to the system composition in general except that the objective is the system composition is to satisfy those requirements. As a result, the system composition band must relate to the two environments on their own terms, and in different ways. The satisfaction of the system design must be shown from the composition of components while sufficient specifications for an implementation of the system composition in the infrastructure band must be developed.

On the right side of Figure 3.1, we map our system design framework onto the specific case of designing a business. To this end, we chose to use the four layer framework proposed by Kumaran (2004). The system definition layer corresponds to the market definition and business design stages, the system composition to the business operations and platform independent IT design stages, the implementation band to the platform independent IT design and platform dependent IT design stages. The business operations stage is the logical design of the business operations required to satisfy the overall or strategic objectives as defined by the business design. As is commonly the case nowadays, the business operations are supported by information technology in their realization. The platform independent IT design stage is where the logical design of the supporting IT system takes place. This design is usually different from the business operations design because very rarely one can completely automate the entire business. (At least so far we have not seen a completely automated business.) The logical design is independent of the software or hardware platforms that might be used for its actual implementation. The platform dependent design is the detailed specification of the supporting IT system that can be built (or purchased or partially purchased and partially built) without knowledge of any of the layers above it. It is a blue-print of the system that can be given to, say, a third party system development group to build it.

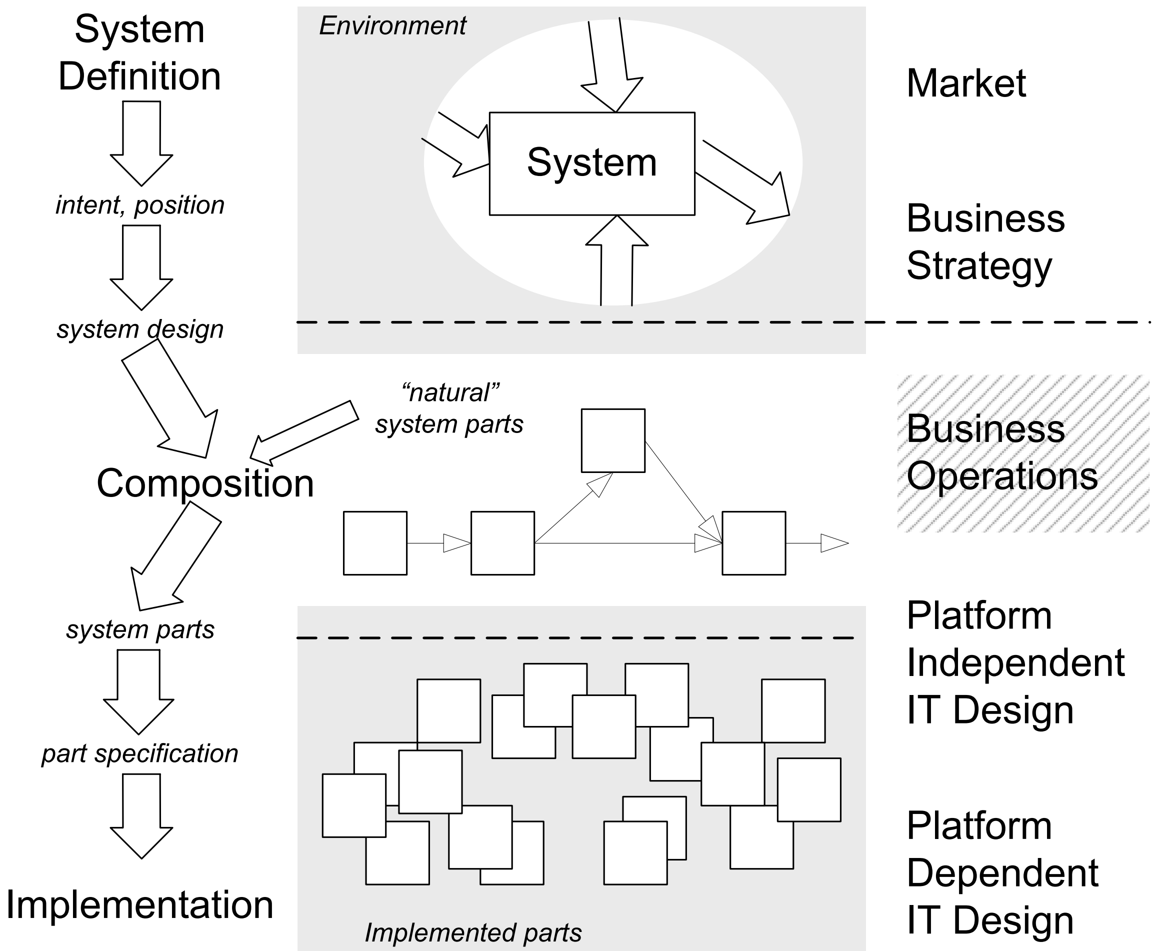

Figure 3.1. A Framework for Business System Design

4. Design and Development of a Business Process and a Manufacturing Process

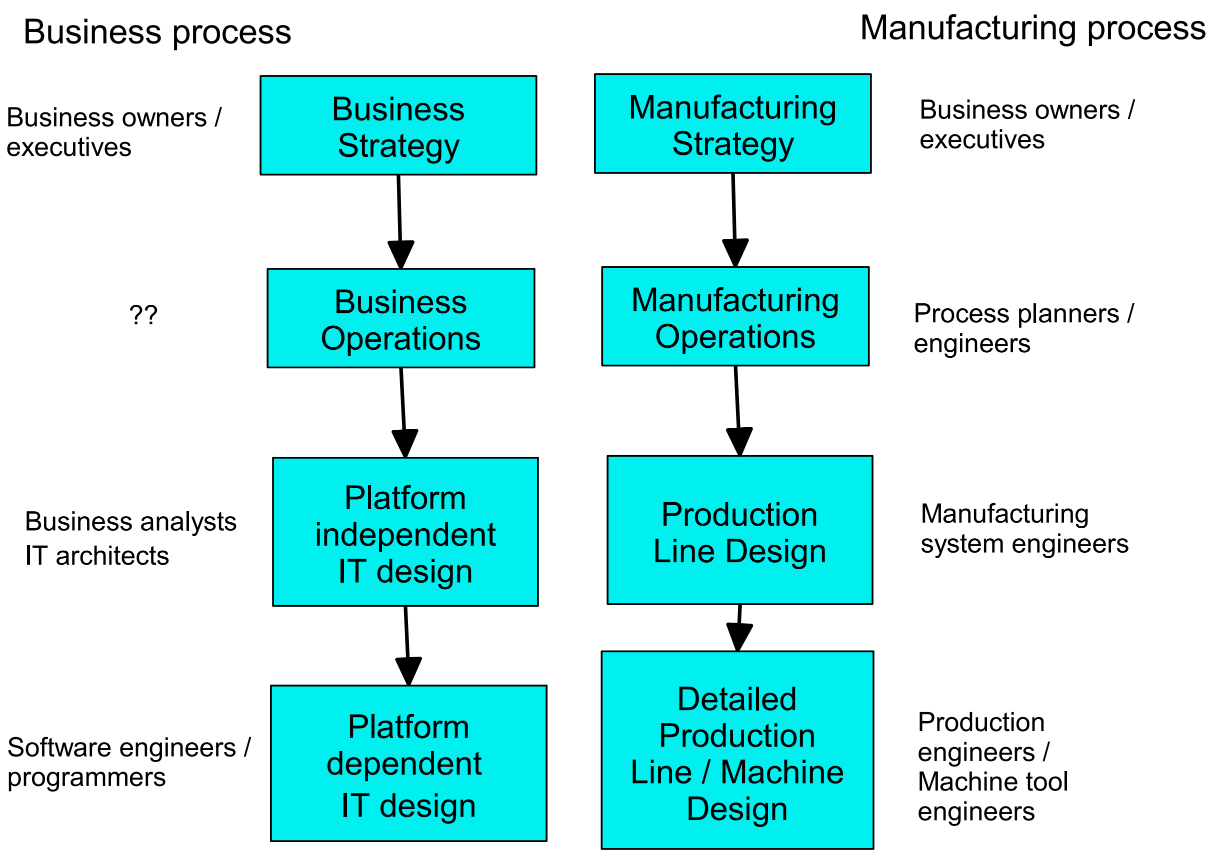

Figure 4.1. Framework for Business Process and Manufacturing Process Design

Now consider the separate cases of designing a business process and a manufacturing process. We assume that the top band in Figure 3.1 is done, i.e., we are given the external characteristics of the system – what kind of deliverable we are trying to sell and is therefore required as output of the process, who are the customers of these deliverables, and the conditions under which these deliverables are provided to the customers. The deliverable could be a physical product or information encapsulated in some physical form (e.g. a report or a publication). This deliverable would be a business artifact in the framework proposed by Nigam and Caswell (2003).

Referring to Figure 3.1, the first step in the system composition band is to determine a strategy on how these deliverables will be made. Figure 4.1 is a slightly more detailed version of the right side of Figure 3.1, including the typical roles who are responsible for the different stages of the business design framework. For a manufacturing process, the manufacturing strategy include specifications such as make or buy, or the extent to which we make the product, the type of production facility – existing or new, job shop or highly automated flow line, etc. Similarly, for a business process, the business strategy will include considerations such as what part of the process is done in house or outsourced the location and nature of the facility - existing or new. Clearly, the exact factors to be considered depend on the nature of the deliverables, the existing business environment and long-term strategy of the firm, the expected volume, profit, and life expectancy of the deliverables and their possible follow-on relatives, etc. At the same time, high level strategic goals are set, such as target lead times, customer order lead times, target work-in-process inventory levels, and finished goods inventory levels.

For illustration purposes, we choose to assume for the manufacturing process that the products will be built in-house using a cellular manufacturing strategy. Further, we assume that we will use product oriented manufacturing cells, i.e. one or few dedicated cells will be designed for the product line in question[5].

Based on the manufacturing strategy, overall planning of the manufacturing operation begins. Figure 4.2 depicts the sequence of activities after setting the manufacturing strategy. The first task in the manufacturing operation activity is to determine a manufacturing process plan for the products to be built, i.e. the processing steps required to transform the raw material to the final product. For example, a metal part may go through the steps of cutting, turning, milling, and final polishing steps. Complex parts may involve subassemblies which can either be purchased or made in-house. So make-vs.-buy decisions for subassemblies or components may be required at this stage. Once the process plan is developed, it will have to be executed by a physical manufacturing facility. Likely the firm already has certain existing manufacturing operation (which may be cellular or otherwise, or a mixture), so the current task is to plan how the new cells fit into the existing facility and what impact they have on the existing operation. At this point only the key input and output of the new cells need to be known – raw materials and end products from the corresponding cells, or any work-in-process which have to be sent outside of the cells for processing, such as to a central paint shop or an electroplating line. In order to ascertain the input and output of the new cells, a very high level concept of the cells has to be developed, such as a preliminary grouping of products into families and assigning families to cells, the type and a rough number of the cells needed. In particular, product grouping is not a trivial task; many approaches and algorithms have been proposed in the literature for product or machine grouping to form manufacturing cells. Chapter 5 in Nyman (1992) proposed an approach for macro facility planning, assuming that the process plans are given and with an emphasis on planning for an entire facility from scratch.

Besides the direct production activities, the requirements of the new cells and new products on planning and control functions (such as production and inventory planning, shop floor order release and scheduling, and materials planning), and other indirect support functions (such as equipment maintenance and shipping) have to be considered. Using the lead time and inventory targets set by the manufacturing strategy, an approach to master production and inventory planning for the new products is devised. Existing planning methods for other products are very useful starting points. The production order release mechanism and intra-cell or department level shop floor scheduling is also designed, taking into account the corresponding processes for other, existing portions of the factory.

Once we have laid out what cells we will have, what goes in and comes out of those cells, and how those cells are controlled (in the production control sense) in the previous "manufacturing

[5]We purposely chose cellular manufacturing as an example. The design of many business processes have much in common with the design of manufacturing cells, as observed independently by MacIntosh (1997). For a comprehensive and up-to-date discussion of cellular manufacturing, see Hyer and Wemmerlov (2002).

operation" activity, we can start to design the innards of each cell. This is the production line design activity in Figure 4.2. In this activity, the conceptual flow of material within the cell is developed, rough sizing of equipment is performed, and a high level layout of the cell is developed. Alternative designs are considered and evaluated using suitable analysis tools, such as simulation. Representative products (such as the basic product in a family) or aggregated products (such as an "average" product in a family) can be used for most of the work here. Chapters 6 and 7 in Nyman (1992) contain a practical approach to the production line design activity.

At the end of the production line design activity, we have a chosen cell design that represents the best cost benefit trade-off with reference to our strategic goals. This chosen cell design will have to be fully developed into an implementable plan, with all details such as the full specification of material handling and production equipment, as well as that of planning and control software and hardware. Sizing of all equipment (i.e. number of machines and their production rate) has to be determined. For decisions such as how many buffer spaces should be allowed for the input and output of each production machine or what is the algorithm for loading jobs onto each machine, detailed analysis using simulation modeling is often necessary. Contrary to earlier activities, all parts that are planned to be produced by the new cells may have to be modeled. Besides performance issues, other aspects such as the handling of deadlocks (if it is a fully automated system) or the handling of reworks have to be considered. Chapter 14 in Nyman (1992) gives a comprehensive account of detailed design with an emphasis on the design of the physical cells. It also touches upon a control aspect – cell scheduling. Other facets of control, such as methods for production planning or inventory management of components and raw materials need to be considered as well. Chapter 15 in Nyman (1992) provides guidelines to equipment specification and request for proposals. Although these guidelines were apparently written with a focus on physical equipment, they also apply to software that is used for planning and control.

In business process design, we go through a similar hierarchy of design/development activities. Nevertheless, there are some fundamental differences:

Because the processing of the deliverable in a business process is mostly information related and will mostly be supported by information technology, the emphasis will be on the logical rather than physical transformation of the deliverable. Physical facility planning will be simplified. For example, the input and output of the process can often be handled physically by a computer or communication network. In other cases where physical transformation is needed, such as an equipment repair, the physical part is typically of small effort relative to the entire service process which includes handling a service call, traveling to the equipment site or the customer shipping the equipment, diagnosis, and getting the required service parts. The coordination of these activities becomes more important than the physical repair operation. Such coordination is a business process with information as input and output.

The nature of an individual operation spans two extremes, from a manual operation carried out by a human operator with possibly large processing times with a high variance, to completely automated operation performed by a computer algorithm with very short and relatively deterministic processing times. Most automated processing steps can in fact be considered to be instantaneous at the logical design stage.

In many cases, information technology is the only "machine" available for automating business processes. At this point in time for most businesses, software is the major issue. Consequently, there is a much more pronounced emphasis on software in the first level process design activities, as can be seen from Figure 4.1.

Further, we observe that the current focus of the software design/development is typically more on the transaction management aspect (e.g., work flow). This is as opposed to manufacturing where significant emphasis is placed on planning, such as materials and inventory planning, or production planning. The equivalent transaction management in manufacturing would be production order management, materials order management, and the like. Clearly this is important to a manufacturing process as well, but is not quite the one and by far the most focused upon. We believe that one day business process design will also place equal emphasis on planning aspects and that they are not there today primarily because manufacturing process design is more mature.

Because a business process usually involves human decisions and interventions, the number of possible paths is large and it is more important to provide exception handling capabilities in the process. This is especially true in service industries where the deliverable is co-produced with the customer and the customer is actively influencing how the process will proceed. Since the customer experiences the process first hand, in a way the business process itself is a deliverable. Hence we see the rise of the topic "experience engineering." (Carbone and Haeckel 1994).

In business process design, given an overall business strategy (discussed above), the next step is to design the business operations. This is composed of several activities, as shown in Figure 4.3. Business process planning is somewhat equivalent to developing a manufacturing process plan, where each operation step and their sequence is specified logically. This differs from a manufacturing process plan in that the focus is on the requirements of the process, i.e., what the process needs to do, rather than the exact detailed steps ("the how"). For example, the operations may include a phone call being received, being routed to the appropriate operator, operator conversing with the caller, and so on. One of these operations may indeed be "manufacturing the product" but only a high level will be considered (e.g. system input and output). Conceptual design will be focused on developing to some detail the necessary steps and their sequence, the logical interaction and impact of the process at hand to existing processes, and physical vicinity of human operators when intensive interaction between people is expected. As well, high level ideas are developed on how deliverables are grouped such that a group is handled by a corresponding set of operators or a particular version of the process. Different logical alternatives are explored, such as combining certain operations, reducing checks and controls, centralized vs. decentralized operations (Hammer and Champy 1993, Buzacott 1996). The level of detail in the conceptual design should be adequate to provide a meaningful comparison of different alternatives in terms of cost, response times, or other measures. One design is then chosen and full fledged details will be developed for that design. With the detailed design, the process should be executable with the appropriate human operators, albeit completely manually.

Note that in Figure 4.2 we have depicted the activities as sequential with one way arrows. However, this is not true in practice; feedback between two activities in sequence exists and the first activity may be revisited after the second activity is partially performed. For example, in the detailed production line design block, we may find that the chosen design may not be able to achieve our objectives (such as production lead time) and we may need to go back to the production line design block to explore other alternative designs that were proposed but not chosen. In fact, the entire manufacturing design block may feed back to the product design block (not shown in Figure 4.2) such that a product design may be modified to make it more manufacturing friendly. Such is the presently well-known principle of design for manufacture.

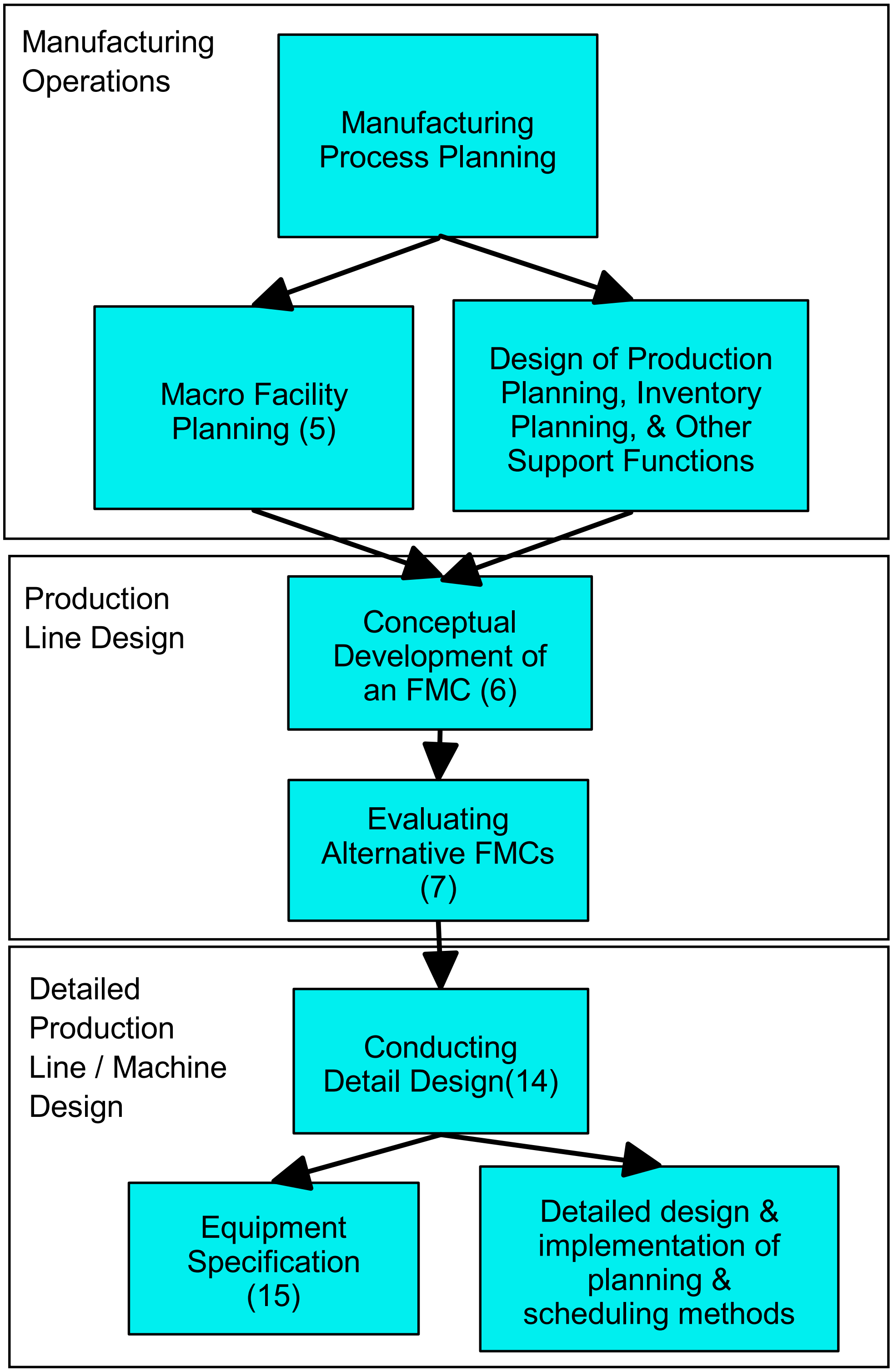

Figure 4.2. Manufacturing Cell Design Framework

(Numbers in parentheses refer to chapter numbers in Nyman 1992)

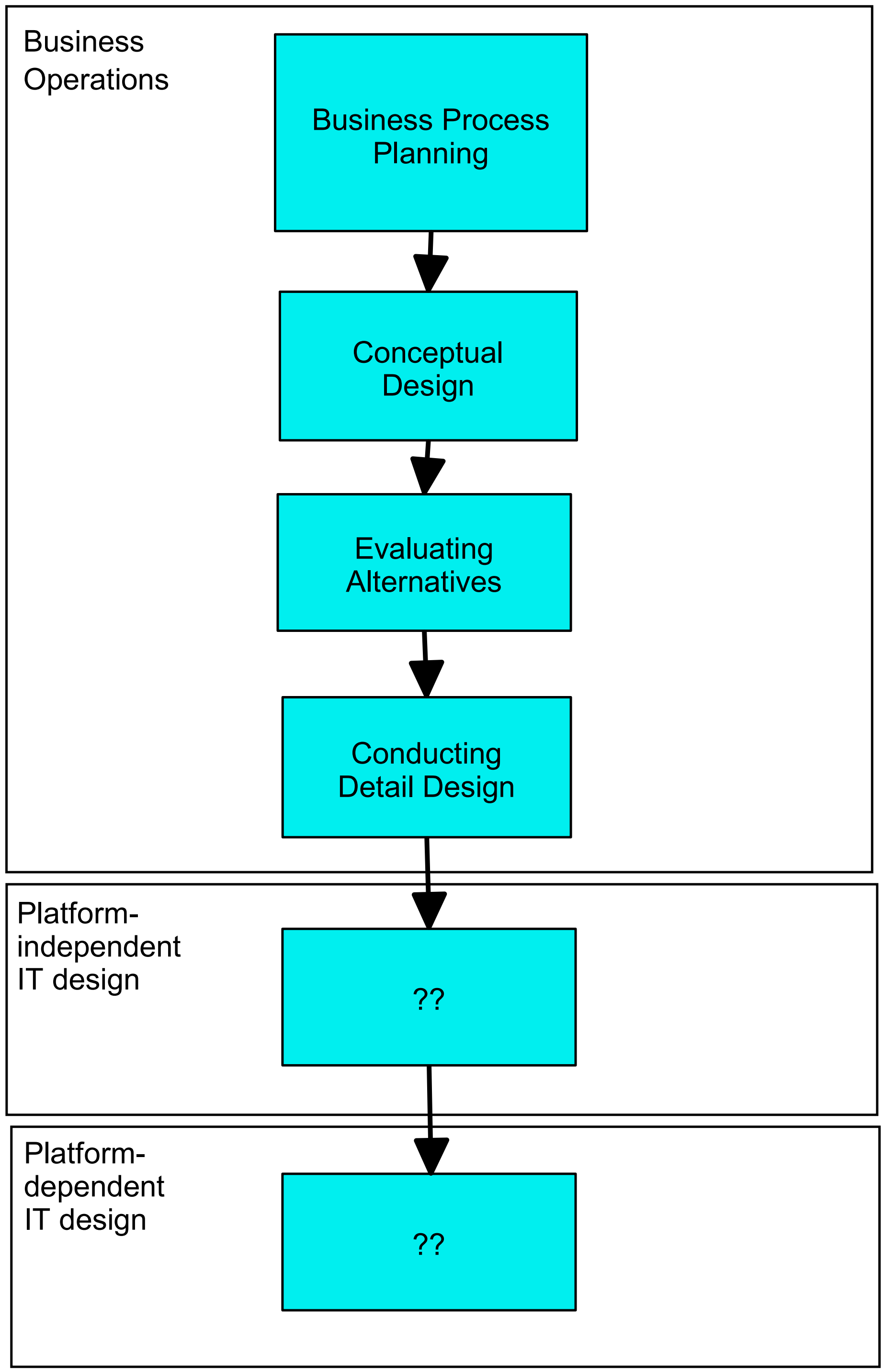

Figure 4.3. Business Process Design Framework

5. The Role of a Business Process Engineer

To date, virtually all business process engineering work (including both one-time re-engineering efforts and continuous process improvement activities) has proceeded under the key assumption that facilitated interactions of subject matter experts (SME) is sufficient to re-engineer complex systems. Business process design work is performed by a multi-disciplinary team selected from organizations currently operating the business. (See, e.g., Hammer and Champy (1993), Towill (1997a, b). More often than not, such design or redesign work is commenced when the business is facing a crisis, such as when it is under intense financial pressure or when it is under severe attacks by new or very strong competitors. Typical teams may include the business process sponsor (sometimes known as executive sponsor), the process owner, the workers who carry out the process on a daily basis (SME's), IT architects focusing on applications and platforms that enable the business operation, IT analysts focusing on the design of end-user applications in the form of user requirements, human resources (HR) or organizational change experts, and perhaps the "customer" of the process. Such experts drawn from the existing business generally have a stake in the status quo. The assumption is that such a team has all the knowledge and skill required to design an integrated system: the only thing they lack is the ability to work together, so facilitation and structuring reengineering activity is required. The latter often leads to the hiring of management consultants who bring a structured methodology or approach that they have used in the past.

The above approach results in "design by committee" solution[6]. Characteristics of such solutions such as local optimization, lack of overall cohesion, lack of accountability, often occur in descriptions of reengineering efforts. Accountability for the design, as opposed to the project management responsibility for meeting dates and budgets, may appear to rest with the process owner role, but this is rarely the case in practice. The process owner is generally an execution role, accountable for producing results from the process, not for the design of the process itself. Changes to the process design are therefore often left to natural adaptation with details determined by the local workers.

Further, changes to policies and rules are inelastic due to the time that it takes to change such things as culture, measures, incentives, communications, and infrastructure. The "organic" adaptation process is diffusion limited, with the rate determined by the gradient between the old and the new (typically really slow for smallish differences) and an equilibrium that may take long or may even be unstable (exploding or oscillating). Instability may occur as a result of changes starting at different places, meeting, and the differences resolving somehow. It is interesting to note that at times there can be all sorts of large changes going on to no particularly productive purpose overall.

What is lacking in this common scenario is a role that takes an active design function focused on the consistency, completeness, and optimization of the system as a whole rather than on its parts. We believe that this role should be filled by a professionally trained business process engineer. The business process engineer possesses skills of process engineering at the general or abstract level and applies them in concrete form to the process at hand. He/she provides expert guidance to the team, leads the team through a structured process of process design and engineering, performs the necessary technical analysis, helps interpret the results of the analysis, and brings in

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[6]Perhaps the comparison point to make here is that the factory level design isn't going to be performed by a production line workers' committee. They are a clear source of input as to what works, what is problematic but do not have the overall, integrating viewpoint.

knowledge of what information and other technologies can provide to support or enable the process. (Today, some management consultants provide some of these capabilities, most notably a structured process or "methodology" to perform business process engineering.)

As Fig. 4.1 depicts, the business process engineer in many aspects plays the analogous role of the manufacturing process planner or engineer:

1. Just as manufacturing process planners or engineers design and optimize a production process plan for a physical product, business process engineers design and optimize a business process to produce the required output, be it an information deliverable or a service.
2. Similar to the make-vs.-buy decision in manufacturing, the business process engineer determines what, if any, portion of the process or deliverable is outsourced or purchased from a supplier. This decision is based on an analysis of the cost, response time, as well as the strategic capability of the business.
3. Just as manufacturing process engineers work with manufacturing systems engineers and machine engineers, business process engineers work with IT architects, analysts, and software engineers for detailed design and development.

Because of the fundamental differences between a manufacturing process and a business process noted in section 4, the business process engineer has a slightly different responsibility in the business operations task (see Fig. 3.1) from that of the manufacturing process engineer in the manufacturing operations task. The following represent the respective implications of the differences in the processes as discussed in Section 4:

1. There is no separate physical production line design task in business process design. The capacity planning of human operators is performed in the business operations task. The business process engineer effectively represents a combination of the manufacturing process engineer and the manufacturing systems engineer.
2. The supporting IT system is usually not a bottleneck in interactive usage mode and is hence ignored in the capacity planning of human operators. In cases where IT system is used intensively and where the computation time is significant, the IT system is usually used in batch mode without human intervention.
3. IT hardware and base operating systems are limited to a few standard choices. Software, either custom built or purchased, is a major focus of the business process design tasks. Further, the software applications supporting a business process are often of an interactive, real time nature. (In manufacturing systems, there are also real time software applications. These are mostly of detailed production control or machine control types, which are outside the scope of the manufacturing process engineer.)

As discussed earlier, today the emphasis is on transaction management software in business process design. In addition, the nature of a business process (as we defined it) usually entails more human involvement. The business process engineer therefore would have a stronger focus on human-human or human-computer interaction, group dynamics, negotiation, and real-time decision making. (In manufacturing systems, there is obviously an important human element to them and past human factors studies have focused on a most directly relevant aspect - humans performing physical tasks.)

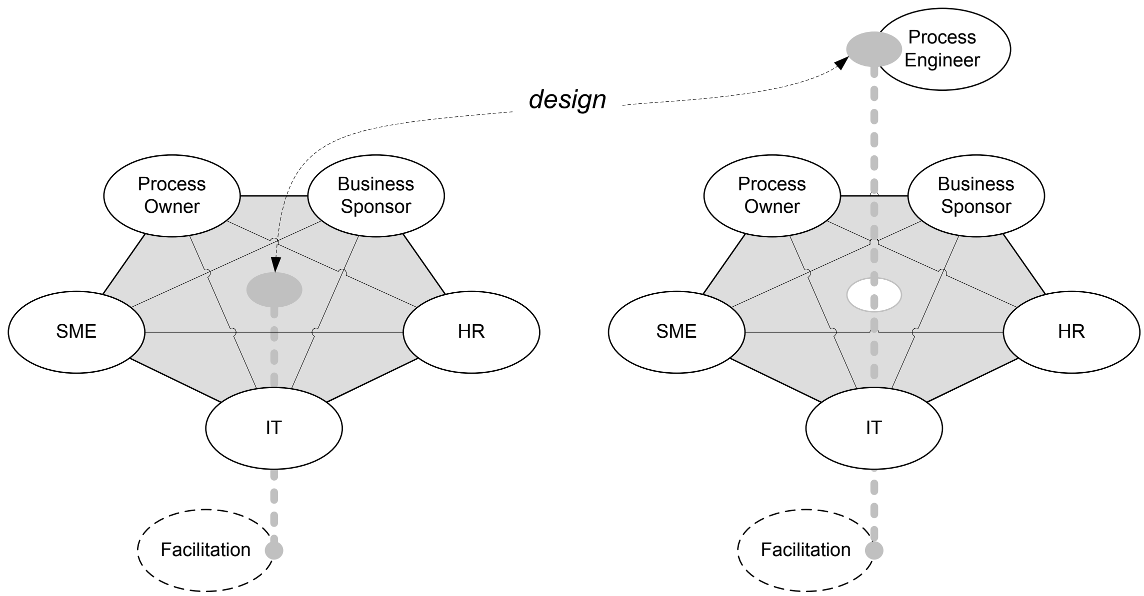

Figure 5.1. Business System Designers: The Present and the Future

It is interesting to note that few industries have existing or emerging roles that are close to a BPE. In hospitals, the role of industrial engineers is filled by management engineers, a well accepted professional job in the field. Hospitals have notoriously complex and potentially inefficient processes, even though they do not make a traditional, physical product. We would like to generalize this role to all other industries.

6. The Skill Set of a Business Process Engineer

6.1 Business Process Engineering Education

The two logical home departments for business process engineering education at the undergraduate and graduate level are Industrial Engineering (IE) and the Business School. The former may present the greatest opportunity to develop and offer such a program because of the current status of IE education and practice, its unique mix of human-technology-business tradition, and the applicability of many of its existing courses. The IE community is beginning to realize that modernizing the curriculum is critical to the future of the IE discipline. Several efforts are underway to define the IE of the future (Askin et al. 2004; Kamath and Mize 2003; Kuo and Deuermeyer 1998; McGinnis 2002; Rouse 2004; Settles 2003). Today's IEs do much more than task-oriented efficiency studies. The scope of IE has gone beyond the design of the physical work place and production processes to the design of systems involving knowledge/information work (Kamath and Mize 2003). BPE is a natural extension of the traditional, physical production space into the non-production space. We submit that BPE should be part of the core program of the "new" industrial engineer.

Business programs have been undergoing rapid changes driven by recent IS/IT advancements. They have taken the lead role in offering programs and options that focus on ERP systems, e-commerce, and supply chains. However, these programs produce mainly business/IS analysts whose primary role is to act as a liaison between the business users and the software developers and vendors. These programs emphasize business and IS/IT concepts and are weak in system design and engineering content. Nevertheless, much knowledge offered by business schools today, such as business strategy, financial planning, business performance measurement, is fundamental to a BPE (as evidenced by our discussion throughout Sections 4 and 5 in this paper). This is similar to the existing relationship between business schools and industrial engineering departments today.

6.2 Critical skills

While an extensive discussion of skills needed by the BPE and their justification is a research subject in itself and outside the scope of this article, we give our preliminary thinking on the key skills for a successful BPE. We note that many of these technical areas are not new in themselves. Some specific techniques and methods have already been proposed in the literature (e.g., Buzacott 1996; Chadha 1995; Osmundson et. al 2004; Park and Park 1999; Rouse 2005; Sousa et al. 2002; Tait 1999; Towill 1997a, b). Others have grown out of other disciplines but have wide applicability in business process engineering. Just like when computer science started half a century ago, many topics then were part of other fields such as mathematics and electrical engineering.

The following is an initial list of critical skills of a BPE. The first three items are most likely covered well in today's industrial engineering curriculum. Some of the rest of the items are taught to different degrees in different subjects, but have not been pulled together as a set to serve a single educational goal. A few of the areas within some items are relatively new, and a substantial body of knowledge on them is yet to be developed. This is a subject of further research.

Business Fundamentals: A basic understanding of how a business operates. Knowledge of functional units, namely, marketing, sales, accounting, purchasing, design, manufacturing, customer service, etc. and their interrelationships. Corporate strategy. Corporate finance. Corporate performance measurement (e.g., balanced scorecard).

Systems Engineering: Requirements gathering, system analysis and design, project management, technical writing and presentation, technical team leadership and management.

Information Systems / Information Technology: Fundamentals of databases. Basic object oriented programming concepts. Design and architecture of Software Applications and Information Systems. Introduction to ERP and e-commerce. Fundamentals of networking, the Internet, and the Web. Markup languages.

Business Process Modeling: Basic probability, statistics, and stochastic processes. Introduction to optimization. Data modeling (e.g., Entity-Relationship diagrams), process modeling and analysis (e.g., IDEF0/IDEF3, queueing networks, simulation, Petri nets), and object modeling (e.g., Unified Modeling Language). Activity-based costing/management. Use of CASE (Computer Aided Systems Engineering) tools. Process metrics and measurement.

Business Process Analysis and Design: Cause-effect analysis. Design of experiments. Reliability and quality concepts as applied to processes. Process design patterns.

Human factors in business processes: Industrial and consumer psychology, group dynamics, relationship oriented computing or social computing, human communication and negotiation, organization and job design, physical ergonomics and information ergonomics.

The Modern Enterprise: Virtual enterprises. Intra- and inter-organizational supply chains. Collaborative commerce. Industry ecosystems. International competition and partnerships. Multi-national and multi-cultural environments.

Domain Knowledge: Selective focus on at least one industry. For example, for manufacturing – manufacturing processes, production control, facility layout; retail – marketing, multi-channel retailing, retail operations; healthcare – hospital operations, insurance operations, health information systems for healthcare professionals and consumers.

7. Concluding Remarks

Business process re-engineering, some ten years after its widely publicized inception as a mainstream tool to improve business performance, is still controversial. Many organizations have varying degrees of success with it. While the concept of BPR is more commonly accepted as a valid approach for a business to stay competitive in today's fast changing environment, how and by whom should a BPR exercise be carried out remains unclear. The issue we explore in this article, namely the non-existence of a professional business process engineer today, is one probable contributing factor to the uncertain results of BPR projects.

Many factors contribute to today's fast changing business environment: unprecedented changes in political landscapes globally, explosion of technological inventions, man-made trends from the fashion and entertainment industries, global competition aided by enhanced communication and the dismantling of trade and political barriers. Undeniably a major factor is the advancement and proliferation of information technology such as the personal computer, the world-wide web, and software technologies that have made IT a much more friendly tool when compared to that of the past. Such IT tools have and will enable the automation and transformation of many business processes and in some cases entire industries. Well-known examples: Rental car check-out at airports, on-line auctions or reverse auctions in the B2B and B2C space, and the process of collecting information for and filing individual income tax. Many of these important transformations have been invented by individual entrepreneurs who relied on their keen observations on certain inefficiencies of a familiar business process. In order to exploit, on a broad scale in all industries, the use of technology in transforming (i.e. more than automating) business processes into more effective ones, we need more resources than the gifted entrepreneurs who, by definition, are only interested in opportunities that are potentially highly profitable to them.

As is widely known in the U.S., the continued shift of the economy from manufacturing to services has underscored the importance of non-production processes (see Table 7.1). It has been estimated that two-thirds of the US labor force belongs to the category of knowledge or information (rather than goods-producing) workers. While our know-how in manufacturing process design and management had propelled U.S. manufacturing to the top in the past, we need to do the same for service industries for the U.S. economy to survive and continue to grow in this changing, global environment. Business process engineering to service industries is the equivalent of manufacturing engineering to manufacturing industries.

It is also essential to note that the government in the U.S., while employing more people than manufacturing in 2000, is largely engaged in non-production activities (see Table 7.1). It can be argued that business process engineering is therefore as crucial as manufacturing engineering, based on the needs of the government sector alone. In this age of emphasis on lean and efficient governments, business process engineering is a crucial subject for the U.S. and other governments in developed countries.

Table 7.1: United States Employment Profile (Source: Fedstats - www.fedstats.gov

Employment in Sector	1990	1995	2000
Manufacturing	17.4%	15.8%	14.0%
Other goods-producing[7]	5.3%	4.9%	5.5%
Private service producing[8]	60.5%	62.8%	64.8%
Government	16.7%	16.5%	15.7%

Further, because IT is almost the sole, and certainly the predominant, technology available for a business process, the success of the IT industry will have an intimate relationship with the success of business process engineering. For one, many requirements of IT will come from the needs of engineering a business process. The days of IT as a pure automation tool are numbered in developed countries. Significant new developments in IT will go hand in hand with new, innovative ways of transforming an existing business process. Major IT vendors (such as IBM) have already recognized this trend, as can be seen by their emphasis on the business transformation business in the recent few years. The continued success of the U.S. IT industry will to a significant extent depend on our success in business process engineering.

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[7]includes mining, construction.

[8]includes transportation, communications, utilities, wholesale and retail trade, finance, insurance and real estate, and services.

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