The Effects of Electronic Collaboration in Reducing Production Time: Product Design Process in SMEs

Marjan Mohammad Jafari, Shamsuddin Ahmed, Siti Zawiah Md Dawal, and Hadi Zayandehroodi

***Abstract*— As global competitive pressure increases and product life cycles compress, SMEs are trying to shorten product development cycles. In the other hand, the rapid growth of electronic collaboration has revolutionized the product development process. This article introduces an electronic collaboration approach that can reduce time during the product design in SMEs. One of the product designs' aim is to reduce production time. Furthermore, the topic has been presented by several authors in many papers for big companies, but still there is a lack of scientific work on SMEs. The main objective of this paper is to reduce product time by e-collaboration. We conclude that there are three aspects in e-collaboration which are extremely important, which are coordination, adaptation and communication.**

***Index Terms*— E-collaboration, Reduce time, SMEs, Product Design.**

I. Introduction

One of the primary goals of new product development (NPD) teams is the reduction of development cycle time. One of the ways for reducing time is by having a design for the product. Product development teams employ many methods and tools as they design, test, and manufacture a new product. Design for Production (DFP) determines how manufacturing a new product design affects the performance of the manufacturing system. Most manufacturing companies have realized that the ability to quickly develop a customized product through an economic and efficient way is critical for them to survive in the violent competitive global market. Likewise, most manufacturing companies discovered that the ability to quickly develop a customized product through an economic and efficient way is critical for them to survive in the violent competitive global market.

The widespread application of the internet and the World Wide Web (WWW) in the last decades has forced manufacturing enterprises to successfully transfer from a conventional centralized manufacturing approach to the modern internet or WWW-based manufacturing pattern in order to meet the rapid changing demand of the international market and competition [1]. Reducing the throughput time has many benefits, including lower inventory reduced costs, improved product quality, faster response to customer orders, and increased flexibility [2].

Much effort is spent to reduce throughput time by improving the manufacturing, planning and control systems and developing more sophisticated scheduling procedures, and these efforts have shown success; however, clearly the product design, which requires a specific set of manufacturing operations, has a huge impact on the throughput time. DFP will become more important as product variety increases and product life cycles decrease. Managing product development cycle times is becoming a major focus of firms [3].

II. E-collaboration and its Evolution

E-collaboration has been defined in many ways in the past. E-collaboration is "collaboration among individuals engaged in a common task using electronic technologies" [4]. According to Cai and Kock, E-Collaboration is defined as collaboration among different individuals to accomplish a joint task using electronic technologies [5]. In that context, Bafoutsou, G has said, "The field of collaborative computing encompasses the use of computers to support coordination and cooperation of two or more people who attempt to perform a task or solve a problem together" [6].

One way people started technological collaboration was from the date of the invention of the telegraph by Samuel F. B. Morse as early as in the mid-1800s [4]. The telegraph allowed individuals to accomplish collaborative tasks, interacting primarily electronically. Such collaboration promoted soon after that, in the 1870s, with the invention of the telephone by Alexander Graham Bell [4].

E-collaboration became a fact after the first commercial computers came in use in post World War II. Those computers were referred to as mainframes. At that time, organizations were very centralized, which inhibited collaborative work. Besides, mainframes were too expensive to be used to support communication and collaboration among groups of individuals. Computer use was limited to only a few specialized operators.

One of the first and most successful E-collaboration tools,

Marjan Mohammad Jafari is with the Department of Engineering, Design and Manufacturing University of Malaya, Lembah Pantai, 50603 Kuala Lumpur, Malaysia (e-mail: marjan_mohamadjafari@Yahoo.com).

Shamsuddin Ahmed is with the Department of Engineering, Design and Manufacturing University of Malaya, Lembah Pantai, 50603 Kuala Lumpur, Malaysia (e-mail: ahmed@um.edu.com).

Siti Zawiah Md Dawal is with the Department of Engineering, Design and Manufacturing University of Malaya, Lembah Pantai, 50603 Kuala Lumpur, Malaysia (e-mail: sitizawiahmd@um.edu.com).

Hadi Zayandehroodi is with the Electrical Engineering Department, National University of Malaysia, 43600 UKM Bangi, Selangor, Malaysia (e-mail: h.zayandehroodi@Yahoo.com).

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a version of email, was, in fact, a spin-off of a wide area computer-networking project called ARPANET, which was sponsored by the US Department of Defence. The project took place in the late 1960s, as the frequently repeated story goes. Arpanet's inventors did envision it as an infrastructure to enable group communication or collaboration. At the time of its initial development, Arpanet was seen primarily as a means for researchers and computer scientists to share expensive mainframe resources [7].

E-mail was initially perceived as a "toy" system, which researchers involved in the ARPANET Project used to casually interact with each other. This perception gave way to one that characterizes e-mail as the father (or mother) of all e-collaboration technologies [8]. In fact, email was detected during the 1970s and 1980s.

As the ARPANET grew, new computer chip production techniques enabled the development of large-scale integrated circuits, with much lower cost. Personal computers have improved, and these personal computers were connected into local area networks (LANs) through LAN operating systems, whose market was initially dominated by Novell Corporation with its NetWare operating system [4]. ARPANET, LAND and personal computers, created E-collaboration technologies in the 1980s. In the 1990s, the ARPANET was evolved into today's present internet, which is cardinally a worldwide network of computers made up of many LANs, interacting through the same general correlation protocol.

III. History OF E-collaboration

The oldest articles about E-collaboration go back to the early mid-1990s. Hitherto researched on topics related to E-collaboration carried a great account, back to the late 1970s. That research was conducted under different ensigns.

E-collaboration research is, in fact, made up of several research streams, with different names and traditions. One such research stream is that of computer-mediated communication, also known as CMC, which has been traditionally concerned with the effects that computer mediation has on individuals who are part of work groups and social communities [4].

E-collaboration research traditions are that of computer supported cooperative work (CSCW), which date back to the 1970s, and whose first inscribed conference, called the CSCW Conference, took place in the early 1980s [9, 10].

As another e-collaboration research tradition, one can mention the GDSSs (group decision support system). GDSS research has grown during the years to become one of the prime locations of research in the broader field of information systems. That research has often attended on the comparison between GDSS tools and group tasks, especially decision-making tasks done by groups of individuals meeting at the same time and in the same room [4].

By the appearance of the internet, especially in the web, many CSCW and GDSS researchers were surprised. Therefore, it brought in researchers from many other areas of investigations into the field of E-collaboration research. Among those disciplines are accounting, marketing, environment, human resource management, psychology, economics, and education (just to name a few).

IV. E- Collaborative design

Electronic collaboration technologies have created an 'information utility' that is accessible, cost-effective, and useful for a broad range of applications. These technologies have been adopted by the manufacturing industry; areas of successful migration to Web-based environments have ranged from collaborative engineering design, shop floor automation, manufacturing execution systems, enterprise resource planning, customer management, supply chain management, and even B2B e-commerce [11]. The Internet and Web-based technologies only provide fundamental infrastructures for collaborative design systems by standardizing communications between individual systems[12], and Intelligent software agents, Internet and Web based technologies are all very useful in developing collaborative design engineering environments and the combination of these technologies has a greater potential to bring advantageous characteristics, such as autonomy, cooperative, flexibility, adaptability, interoperability, scalability, and loosely coupled message based architecture [12].

V. Design for production

In general, DFP refers to methods that determine if a manufacturing system has a sufficient capacity to achieve the desired throughput and methods that estimate the throughput time. These methods require information about a product's design, process plan, and production quantity along with information about the manufacturing system that will manufacture the product. DFP is related to the product's manufacture. It implies that DFP evaluates how many parts the manufacturing system can output and how long each order will take; that is, it evaluates manufacturing capacity and measures the manufacturing time. DFP can lead a product development team to consider changing the product design. In addition, DFP can provoke suggestions to improve the manufacturing system. Some have used various names to describe DFP approaches, including design for localization [13], design for existing environment [14], and design for a schedule ability [15], design for manufacturing system performance [16], design for speed [17], and design for time-to-market [18]. Furthermore, some of these researchers have reported case studies in which product designs were modified to improve production. However, important work of DFP will focus on: capacity analysis, design guidelines, and estimating throughput times [2].

A. Capacity Analysis

Capacity analysis compares the manufacturing system's capacity to the product design's requirements. The manufacturing system's capacity depends on the time available at each required resource and the time already allocated to fabricate other products. The product design's requirements depend on the setup and processing time at each operation and the desired production rate. Therefore, capacity analysis can determine whether sufficient capacity exists or estimates the maximum feasible production level and in some case suggests other release dates as well as changes that would increase the manufacturing system capacity. In these interpretations, Taylor, English, and Graves [19] used a

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capacity analysis model to determine the maximum production quantity that an electronics assembly facility can achieve, and then Bermon, Feigen, and Hood [20] presented a capacity analysis model for a manufacturing line that produces multiple products. By the way, many authors have described capacity planning methods that are part of traditional manufacturing planning and control systems (Hopp and Spearman [21]; Vollmann, Berry, and Whybark [22]). At a glance, typical objectives include minimizing equipment costs, inventory, and throughput time. Different capacity planning models vary, and the more accurate methods require more data and more computational effort.

B. Design Guidelines

Design guidelines help the product development team create a better product design. Many design guidelines exist for specific manufacturing processes, and these remind designers to leave sufficiently large corner radii, to avoid undercuts, and to minimize the number of components, for example, Kusiak and He [23] suggested rules that designers can follow to reduce a product's throughput time. In addition, these rules attempt to simplify the production scheduling problems that plague most production systems. For instance, the rules state that one should minimize the number of machines needed to manufacture a product and allow the use of substitute manufacturing processes.

C. Estimating Throughput Time

Previous DFP approaches estimated throughput time either by modelling the steady-state performance of the manufacturing system or by scheduling or simulating manufacturing systems that are evolving as the product mix changes over time. Herrmann and Chincholkar[24] had presented a set of models that can be used to estimate the throughput time of a new product. In this sense, Seepersad, Hernandez, and Allen [25] suggested a throughput time analysis of a heat exchanger tube manufacturing facility and an approach for optimal design of these tubes using a product platform-based approach. Singh [26] calculated the time at a manufacturing operation, as the sum of the setup time and the run time. In other aspects, Govil [27] assumed that the throughput time at each manufacturing operation is a one time period. An approach for comparing microwave module designs described in detail by Meyer et al. [28] and later Veeramani and Joshi [29]. Veeramani and Mehendale [30] expatiated a system that allows a manufacturer to respond quickly to requests for a quotation (RFQs). Make-to- orders manufacturing system and builds a model that can determine the delivery date of a single customer order which explained by Elhafsi and Rolland [31]. Similarly, Soundar and Bao [32] came up with a plan to address the question of determining how the product design affects the manufacturing system.

VI. Past research about reduce time

Some academic researcher discusses different ways for shortening the cycle time. For example, it proposed a hierarchy of approaches firms might use to accelerate new product development [33]. It investigated the effects of specific factors on cycle time by drawing inferences from a small sample (35 or fewer cases) studies [34], [35], [36], [37], [38], [39], [40]. Therefore, it is proposed that conceptual models for relationships between the product development cycle times and a number of different factors [41]. Hamdi A. Bashir has done a modeling of development time for hydroelectric generators. The model uses three factors, namely, product complexity, involvement of partners in the development process, and generator speed [42]. Jeffrey W has presented an approach that can reduce the throughput time during product design. Design for production (DFP) determines how manufacturing a new product design affects the performance of the manufacturing system. This includes design guidelines, capacity analysis, and estimating throughput time [2]. Lasse T.T. Pesonen describes ‘‘Product Process Decision Simulation” (PPDS) solution as the first implemented application of the approach. A dynamic model of product development has been created and applied to manage product process complex dynamic behaviour on system level in order to reduce the product development cycle times, slippages and costs as well as improve perceived product quality [43]. Ai Qingsong used five tiers for rapid mould product development in his model; these five tiers include a user interface tier, a web server tier, an application tier, a service tier, and a knowledge-based tier. And in the injection moulding enterprises, the product information tool information and the manufacturing information are the two most important information to support the collaborative mould product development [1]. Dunbing Tang presented a design structure matrix (DSM) to capture and manage the system-level design knowledge [44]. Thomas A. Roemer presented two approaches that synchronize production flows through the manufacturing system for reducing manufacturing lead times [45].

VII. Definition Of SMEs

There are many accepted definitions of SMEs and the classifications vary from industry to industry and from country to country, different countries adopt different criteria such as employment, sales or investment for defining small and medium enterprises. In the absence of a definitive classification, a consensus has developed around the European Commission (EC) criteria for SME classification; this definition adopts a quantitative approach emphasizing “tangible” criteria, employee numbers (up to 250 employees), turnover and balance sheet statistics [46].

VIII. Conceptual model

A. A model of the factors affecting development time performance

A presented model by Zinger and Janet for development time is shown in Figure 1, and they have proposed three factors for demonstrating their model; namely, product strategy, development process, and development team structure variables [47].

1) Product Strategy

Choosing a product strategy that minimizes the amount of product and process change is cited in the literature as one way for firms to reduce the product development cycle time.

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Two techniques that minimize the number of product and process design activities are incremental product change and reduction in a number of product parts.

a. Incremental Product Change
b. Part Reduction

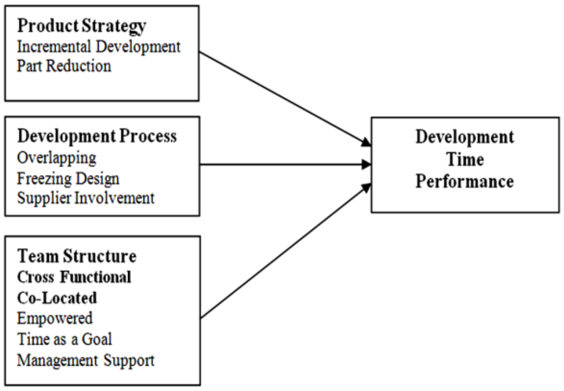

Figure 1: A model of the factors affecting development time performance

2) Product Development Process

a. Overlapping Development
b. Freezing the Product Design Early
c. Supplier Management

3) Development Team Structure

Altering the development team's composition and management has also been discussed as a means to accelerate product development. We tested five techniques that address the development team's structure which are as follows:

a. cross-functional development team
b. dedicated team members
c. co-location
d. decision making autonomy
e. time as a goal

B. A model of E-collaboration effects

Figure 2 shows a model by S.Qureshi for the management project [48]. The main factors in this model are communication, adaptation, and coordination.

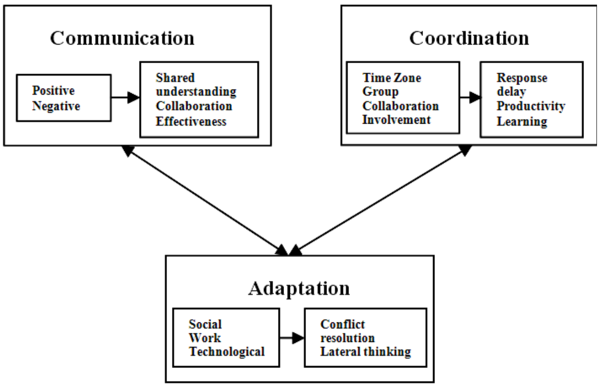

Figure 2: A model of E-Collaboration Effects

1) Communication

Communication was found to play a central role in the virtual team performance. Effective communication means not only passing the information to the receiver, but also understanding and utilizing the information passed. Teams operating in the virtual environment face greater obstacles to orderly and efficiently information exchange because they rely heavily on information technology to communicate [49]. The results of the coding suggest that there were numerous issues with communicating electronically. Episodes relating to communication were both positive and negative. The consequences of these episodes affected the extent to which the virtual team was successful.

2) Adaptation

Adaptation is the process by which members of a group learn to engage with themselves, the distributed work environment and the collaborative technologies with which they work. Virtual teams need to adapt their practices constantly to the organizational challenges in three aspects: social, technology and work adaptation. Virtual team members need to change their own way of doing things to adapt to the virtual environment. It affects the work process itself and the way in which work is carried out [50].

3) Coordination

Coordination is a challenge between teams and management and these challenges are many but, opportunities exist. "Leadership in virtual teams varies widely as a function of circumstances and culture. However, a rotating style of leadership is especially popular. As such, "leadership is based on characteristics of the task at hand and the fit of a particular team member with that task" [51].

C. A purpose model

The main idea in this research is reducing time by electronic collaboration. Companies can productively enter the global market if they can complete the customer's needs regarding features and quality of products. For this research, it is supposed that the most important item for competition in the market is time. The author will combine two models about e-collaboration and development time performance for reducing time.

IX. Conclusion

The fields of e-collaboration have a promising future, in terms of both academic research and commercial software development. As an area of academic research, E-collaboration has flourished since the 1980s and particularly in the 1990s. As an area of commercial software development, E-collaboration is likely to benefit from a critical assessment of how it can be applied to the benefit of individuals, organizations and society. In this article, the authors have provided some concepts and definitions, such as E-collaboration, a historical review of E-collaboration, past research on E-collaboration, and a design for production, which has been defined as a relationship between e-collaboration and time reduction.

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