Virtual Collaborative Design

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INTRODUCTION

As we enter the third millennium, many organizations are forced to constantly pursue new strategies to differentiate themselves from their competitors. Examples include offering customers streams of new products and services, as well as continuously seeking to improve productivity, services and the effectiveness of product design, development and manufacturing processes. Consequently, new concepts, approaches and tools are emerging quickly as the globalization trend expands across the world. Product complexity, pressures to reduce production cycle time, the need for stakeholders' contributions and multinational company as well as consumer requirements create the demand for sophisticated multi-designer collaborative virtual environments where product design can be shared and acted upon (Kunz, Christiansen, Cohen, Jin, & Levitt, 1998; Ragusa & Bochanek, 2001; Anderson, Esser & Interrante, 2003). Thus, researchers and practitioners recognize that collaboration is an essential aspect of contemporary, professional product design and development activities.

The design process is collaborative by nature. Collaborative design fosters participation of stakeholders in any form during the design process. The design of a successful product is dependent on integrating information and experiences from a number of different knowledge domains. These domains include consumer (end-user) requirements, industrial designers' professional design skills as well as manufacturers' needs. This results in a product that performs at a functional as well as aesthetic level and that can be manufactured by the right process at the right price. End-user involvement is essential to product design, since products that do not achieve consumer satisfaction or meet consumer needs are doomed to fail (Schultz, 2001). Accurate understanding of user needs is an essential aspect in developing commercially successful products (Achilladelis, 1971). Hence, it is very important for industrial designers to gather the end-users' needs and incorporate them into their designs. The involvement of manufacturers in the initial stages of the domestic product design process can lead to a dramatic reduction in a product's development lifecycle time, also facilitating the coordination of the purchasing and engineering functions (Bochanek & Ragusa, 2001; Demirbilek, 2001).

The increasing complexity of artifacts and the globalization of product development are changing research methodologies and techniques. A prime example of this includes the application of a virtual collaborative design environment (VCDE) for product design and manufacturing.

This article focuses on the concept of virtual collaborative design. It describes a research effort to investigate cross-cultural collaboration in product development using online applications for domestic product design. The aim of this research is to investigate issues related to the virtual collaborative design (VCD) process, and to bring an understanding of stakeholder needs during the collaborative design process as well as to improve the relationships between end-users, designers and manufacturers. The article presents findings based on a survey study conducted with four different potential stakeholders: representatives of consumers, software designers, industrial designers and manufacturers.

VIRTUAL COLLABORATIVE DESIGN

The design phase of a product is considered to be one of the most critical phases of product development, as most of the decisions regarding product cost and time to market are made at this stage. With the development of new technologies—for example, computer-aided design (CAD) tools, virtual reality (VR) and virtual design environments that use 3D CAD—many organizations have started utilizing computer-based technologies in product design and development. The application of VCDE has attracted researchers and practitioners in recent years due to its potential benefits. First, VCDE empowers designers by allowing design activities to be performed simultaneously. Second, it brings flexibility to the design process, as designers can enter the system anytime to perform design work; for example, whenever they have new inspirations for possible design solutions or to jointly evaluate design issues and ideas. Designers, no longer confined to their offices, instead actively participate in collaborative de-

sign projects. Third, VCDE allows designers to form virtual teams and to work with potential consumers and define the individually customized shape of a requested product (Horvat & Rusak, 2001; Kunz et al., 2001). Fourth, requirements and design evaluations are built, and design errors are identified earlier rather than during the manufacturing stage or customer use (Bochanek & Ragusa, 1998). Finally, it has a potential to reduce overall product development time, cost and time to market, while improving product quality (Bochanek, Ciarelli, & Ragusa, 2003).

Eighty-five percent of product development costs are determined before the product design is released to manufacturing (Will, 1991). NASA has initiated a VCDE development project to support design activities for modifying structural components of their spacecraft (Mapar, Brown, Medina, Laskey, & Conaty, 2001) in anticipation that the VCDE will help users reduce design cycle time and contribute to faster development of products for space missions. Several organizations have reported positive outcomes as a result of virtual collaborative environment technologies. For instance, design work for 777 aircraft in Boeing Corporation was reduced by 60% to 90% (Keller, 1998). In a similar way, DaimlerChrysler Corporation reported cost savings of $75 million and a 20% reduction in its intrepid model development time for their new vehicles (Keller, 1998). The United States department of defense supports the usage of simulation-based programs that reduce system acquisition cycle time by 50% and significantly cut the overall cost to acquire future military weapon systems in product design and developments (Bochanek & Ragusa, 1998).

CASE STUDY

VCDE brings critical perspectives to the process of design, as it fosters the involvement of all stakeholders. Demirbilek and Aurum (2003) developed a VCD model for online applications and investigated the involvement of potential stakeholders in the product design process; namely, consumers (end users of the product), industrial designers, software designers and manufacturers. This article reports the above stakeholders' viewpoints using a case study.

This case study employs a fictitious furniture company that fosters the VCD process model. The study uses the design of a dining chair as an example, in which the stakeholders take a proactive approach to the design process. For instance, the users (consumers) are able to determine and modify the foreseen functions on one product, as well as deciding on: (a) the form; (b) dimensions and proportions; (c) colors; (d) materials and textures; e) finishes; and f) cost of the product. Furthermore, the proposed system helps both software and industrial designers evaluate the product in order to verify a design outcome under real conditions. Finally, the introduction of the manufacturer in the early stages of development aims to reduce the domestic product development life cycle.

A survey was conducted with four groups of 82 target subjects representing potential stakeholders. The first group, representing consumers, was made up of computer-literate commerce students. The second group, representing industrial designers, was made up of industrial design students. The third group, representing software designers, was made up of software engineering students. The fourth group, representing manufacturers, was made up of mechanical engineering and manufacturing students. Four sets of survey questionnaires were developed, each addressing a different stakeholder; that is, consumers, industrial designers, software engineers and manufacturers, respectively. The questionnaire consisted of both open-ended and closed questions.

The primary aim of the survey was to investigate stakeholders' viewpoints and to gain a deeper insight into virtual collaborative design, which fosters involvement of stakeholders and shared understanding.

RESULTS

The following results from the survey are grouped based on stakeholder type.

Consumers

The average computer usage among subjects was 7.5 hours per day. Sixty-four percent had already had an online shopping experience. Their primary reasons for engaging in online shopping included lower price, easy access to available products and convenience. Eighty-two percent of subjects were interested in using VCDE, and 50% expressed an interest in using VCDE to design and purchase a product such as a dining chair. Forty-three percent of participants displayed a desire for having more control during the design process, while 36% expressed that they would like to use the system for its novelty and 19% expected to cut costs by designing the products themselves. However, only 41% of consumers were willing to pay for using VCDE, provided that it would not cost more than 5% of the final product. Interestingly, 35% of participants thought that the final decision in the design process should lie with consumers, 30% said it should lie with industrial designers and 28% thought that all stakeholders should have equal control in the design. Although most of the subjects were keen to use VCD