

Innovative Approaches to Collaborative Design Projects

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Abstract

Rapid changes in technology and a global economic recession have prompted many leading manufacturing companies to reevaluate and upgrade their design and manufacturing process. An increasing number of these companies have moved from traditional design environment to a virtual one. Companies such as Boeing have utilized various new software/tools and adopted innovative technologies to reduce cost and time to market for new products. In response to these changes in industry, engineering schools have also reevaluated and realized their curriculum particularly in area of collaborative design projects. The objectives of this paper are (1) to review the existing software/tools and methodologies used in design processes, (2) to introduce innovative approaches to collaborative design environment, then (3) present several funded case studies employing new cutting-edge technologies.

Introduction

The field of collaborative design (CD) has enjoyed considerable attention and success over the last decade as rapid changes in technology and a global economic recession have prompted many leading manufacturing companies to reevaluate and upgrade their design and manufacturing process. An increasing number of these companies have moved from traditional design environment to a virtual one. but CD is now facing some of the pains expected along with its growth. Based largely on virtual collaborative premises, CD is adjusting to cognitive ways of viewing the design process. Originally a primarily linear process, CD is embracing new methods and computer design tools that allow greater flexibility in the management and order of design activities in a virtual environment. Our purposes in this paper are (1) to review the existing software/tools and methodologies used in design processes, (2) to introduce innovative approaches to collaborative design environment, then (3) present several funded case studies employing new cutting-edge technologies.

Existing Methods and Technologies

From its inception, CD practice has fallen short of its ideal prescriptions. Based on cybernetic principles of general design theory, the ideal design process relies on constant systemic feedback. Such a system acts something like a thermostat, always monitoring its own effectiveness, making revisions as needed to optimize the outcomes. These cycles of self-testing and correction are repeated during the design process as well as during implementation and maintenance. In practice, however, CD methods tend to proceed in linear fashion from defined

needs and goals. Once the needs are identified and goals are defined, designers rarely look back. Instead, they tend to move through planning, design, and development phases in lock-step order. This has been necessary because of the enormous cost of cycling back to previously "completed" phases. Designers, sensitive in the first place to criticisms of cost, have been loath to truly apply the iterative cycles of review and revision prescribed by CD theory. The application of CD is further weakened when tasks are compartmentalized and team members isolated from the rest of the system and each other as is the case when members of design teams are physically located in different locations around the country or even world. In many large projects, an individual member of design team may specialize in task analysis and never interact with designers at later stages. In short, the exigencies of the situation have made the application of CD impossible. For certain kinds of well-defined design within stable training environments, the linear approach may work satisfactorily. However, the limitations of linear CD become apparent when working in ill-defined design domains, or when working with highly diverse design team members who are located in different locations.

In response to this problem, a number of techniques and technologies have been developed to allow designers greater flexibility in design activities. Several of these are discussed below.

Rapid Prototyping

Recently, designers have been using a method for developing a prototype for design evaluation. At early phases of design implementation, a small-scale prototype is built that shows important features of the intended product or system. This prototype is studied and evaluated in order to have a better understanding of actual design or system. Some prototypes are smaller in scale than original, or scrapped after the design stage. Some prototypes are produced to actual size and shape and taken to industrial shows to evaluate the market demand for that product. If suitable, the product will then be produced in larger quantities. The advantages of prototyping are that it allows for evaluation of key features of product or system at early stages of design when costs are not too high and changes can be easily made.

Rapid prototyping applied to CD will allow designers greater flexibility in defining the goals and form of design at early stages [1]. Rapid prototyping can be relevant to all kinds of design projects, but its value is most apparent in the design of computer-based systems. Imagine developing a sophisticated multimedia system strictly from identified needs and goals and without early working prototypes! Easy-to-use authoring programs such as HyperCard or ToolBook are commonly used as prototyping tools because of their power and flexibility

It should be clear that rapid prototyping could help designers break out of the linear approach to design. Rapid prototyping is also more in line with how people actually solve problems in other domains such as instructional design, which is far from a linear process.

Automated CD systems

CD can be greatly facilitated by computers, making the process more efficient and flexible. There are three basic ways computers can help to automate CD procedures:

1. *Data management.* Bunderson and colleagues [2] described CD as a loop that begins with analysis of expert performance and ends with learners demonstrating that same expertise. In

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between, designers produce reams of paperwork, generating a "lexical loop." Such a process is badly in need of a database that can organize and interrelate a project's needs, goals, objectives, tests, and instruction.

2. *Task support.* A wide variety of design tasks can be supported by computers, ranging from graphics production to word processing to communication among team members.

3. *Decision support.* Computers can assist in many design decisions by providing aids such as:

--ready access to information

--checklists

--templates

--expert system advisors.

Innovative Approaches to CD

As we discussed earlier, designers have been employing various methods and technologies to change linear design process to more interactive process. However, in today's competitive market, global out-sourcing is causing industrial products to be developed in virtual teams to reduce costs and development times [3]. Therefore, designers need to learn how to collaborate in a virtual environment. Here product teams must design and manufacture new products where the team members are not co-located in the same place at the same time [4]. It is important to introduce this into the classroom, because virtual interactions are becoming increasingly important as separated teams jointly develop products.

A number of efforts have been underway to develop comprehensive systems that automate the CD process especially. Most of these are in prototype form, but we focus on one new software entitled "ipTeam Suite software by Nexprise, which has been successfully used by leading manufacturing companies such as Boeing for CD in a virtual environment.

ipTeam Software

The ipTeam Suite software provides a medium for team interaction and supply chain management during the design process. This powerful software provides a virtual environment for a cross-functional development team to design new products around the needs of the customer. A cross-functional product development team involves members from all of the enterprise's functional disciplines, e.g., design, manufacturing, marketing, purchasing, and quality assurance. The enterprise that is supported by this software includes the supply chain, which is becoming an important part of every company.

The features of ipTeam Suite software will be briefly described in this section. The model that ipTeam Suite uses for its environment is a project area. Physical project areas require the use of the design notebooks, document configuration control, management plans, and interactions with subcontractors and suppliers. The ipTeam Suite software supports all of these in a virtual environment, and they can be linked together. The design process is iterative whereby the design

concepts are selected, and the team continuously makes changes until the final design is chosen. The team must be able to record their design concepts, changes and the information that is used to make their decisions. Everyone on the team have to be able to use the ipTeam Suite notebook to document his or her designs. The iNotebook provides a work area that the team could use to exchange design information synchronously. The document vault provides the configuration control of documents. Documents could be placed in the vault and then reviewed and revised by all of the members of the team. The iMail and iRoute portions to the environment are used to coordinate and notify team members that new information or documentation was posted on the web site [5].

Funded CD Pilot Projects

Several grants from Lemelson Foundation were used over past four years to offer joint CD projects between inter-universities and their global industrial partners utilizing ipTeam software from Nexprise, Inc [6]. These joint web-based courses were team taught by faculty from participating institutions and their industrial partner in US and abroad. The ipTeam Suite was used by the instructors to coordinate work and assignments. The lecture notes and assignments were made available to the students as soon as the class was finished with the classroom document vault. The student teams would then coordinate their work from the assignments in the document vault. Each student team had its own project area with its document vaults, design notebooks and workflow routers. The teams used these areas to develop their product designs. The lecturers could verify that the assignments were being completed in a timely manner by reviewing the work in each of the project areas. The lecturers could also know where the teams were weak and the subjects that would require more emphasis in the classroom.

ipTeam Suite supported the design and development of new products for virtual teams. It provided the communications infrastructure through its use of email, workflow routers and the use of web browsers as the primary user interface. ipTeam Suite was the data retention infrastructure for virtual teams with its virtual project areas, which contained document vaults, virtual notebooks, scheduler and consensus builder. ipTeam Suite used commercial secure servers, which worked with corporate firewalls to provide security for the virtual team and its information products. Each virtual team member is authenticated before information is accessed. Since the server can be accessed across the World Wide Web with a web browser, virtual teams can be formed across corporations that are located anywhere in the world.

The virtual teams interacted through their communication and data retention infrastructures. The communication infrastructure supported synchronous work and allowed the teams to coordinate their synchronous work. Synchronous work occurred when team members were working together to create the same new information at the same time. Asynchronous work occurred when the team members worked on different information or work at different times. The data retention infrastructure allowed the team members to share and modify information across the team. It allowed the team members to resettle information, as it was refined across the life of the product. Both of these factors enabled a virtual team to work and create its products.

Conclusion

Technology is changing so rapidly, and an increasing number of manufacturing companies are embracing and implementing new technologies into CD environment, in order to stay competitive in the global market. Colleges and universities have an obligation to embrace these new technologies and integrate them into their capstone design curriculum. In order to truly prepare the new generation of design and manufacturing engineers for challenges of this new century, colleges and universities have to revitalize their capstone design courses. They need not only have to offer these virtual-based courses to their own students, but they also need to collaborate with other universities to offer these courses to a global student population as well.

In this paper, we examined some existing and also new methods and technologies needed to globalize CD projects. We also presented our own personal experience with ipTeam software in several funded pilot projects. We believe by adopting these technologies into design curriculum, engineering schools will have the same potential of improving their programs that leading manufacturing companies have enjoyed through the integration of these technologies into theirs.

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