Web-based Enhancements for Designing and Developing Integrated Product Realization

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Abstract *- The design of Integrated Product Realization (IPR) responds the call for better problem solvers in engineering education. IPR integrates systematic product launch methods with practical application. Contrasting conventional instruction, the design of IPR is characterized by using real-world problems as a context for students to acquire knowledge and skills in the product development process. With its reality-based learning approach, students will learn the concepts, principles and techniques in product development through playing the role of active problem-solvers. Instead of instructing students how to do the project, instructor will facilitate the process of defining problems, gathering and synthesizing information, and generating problem solutions.*

In this paper, we will describe how we utilize web technologies to assist students working on their real world projects, how we integrate these collaborative online spreadsheets with the product realization case study and how students have successfully utilized this approach to develop a sub-assembly for an industrial customer.

Index terms:Case study, integrated product realization, problem-based learning, web-enabled technology

INTRODUCTION

Engineering education calls for better problem solvers and knowledge users. One of the courses designed by Greenfield Coalition, Integrated Product Realization (IPR) addresses this call. IPR integrates systematic product launch methods with practical application. In this course, students analyze and design real world products based on customer needs utilizing a series of robust processes. In learning the process of designing and developing a product, students develop an understanding of the complexity of industrial practice and various roles that team members play in the process of product development.

IPR utilizes a series of processes to generate detailed CAD drawings from a product concept. These processes accounts for various manufacturing and other business constraints to ensure that customer needs will be met. Also, this course examines the fundamentals of project planning and execution for manufacturing engineering products. The course is also designed to help students develop effective project management skills in planning and coordinating resources and tasks to achieve high-quality, low-cost products while making efficient use of time, money, and other resources. Students will acquire skills and tools for planning and representing task dependencies and timing, creating product development plans, rapidly executing projects, and evaluating and improving projects.

Contrasting conventional instruction, the design of IPR is characterized by using real-world problems as a context for students to acquire knowledge and skills in the product development process. With this reality-based learning approach, students will learn the concepts, principles and techniques in product development through playing the role of active problem-solvers. Instead of instructing students how to do the project, instructor will facilitate the process of defining problems, gathering and synthesizing information, and generating problem solutions. Instructors also scaffold the learning process through providing resources, guidelines and tools using web-enabled technologies.

INSTRUCTIONAL DESIGN APPROACH AT GREENFIELD COALITION

The Greenfield Coalition (GC), located at the Focus: HOPE Center for Advanced Technologies (CAT) at Detroit, operates as a virtual university where university and industry partners work cooperatively to deliver engineering degrees to a student body composed of 95% underrepresented minorities. GC offers an environment where classroom learning can be directly applied to their jobs on the shop floor. To design this learning experience, we take the projects from the shop floor and frame the concepts and principles to be learned around these problems. Students will more actively involved in learning new knowledge and skills and more responsible for their own learning where learning activities are structured in this authentic problem solving setting.

With reality-based learning approach, student assessment is performance based. Students are not evaluated

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by book knowledge, rather they are assessed based on their project deliverables or outcome of problem solutions.

Reality based activities come from the projects or problems that occur in the real world. In RBL, we bring working experience to classroom and transfer learned skills back to the work environment. At Greenfield Coalition at Focus :HOPE, students work in different manufacturing operations while going to school. This environment allows us to select a variety of real world problems for students to solve in the area of machining, sales, purchasing, engineering design, shipping, and assembly line, etc. For students in a more conventional educational setting, these problems can be simulated via the web-enabled technologies, such as graphics, animations, simulations, video clips and/or transcripts, interactive tools, references, and relevant documentations.

USING WEB-ENABLED TECHNOLOGIES TO ASSIST STUDENTS PROBLEM SOLVING

At onset of the course, students are presented with two real world projects in different manufacturing environments. One project is to design a mechanical pencil, and the other is to redesign a sub-assembly based on the customer's functional specifications. Throughout the course, students will work cooperatively in group to solve the ill-structured problems where there is no single solution.

Designing mechanical pencil

Choosing mechanical pencil as a term project has some advantages. The problem is real and students are familiar with the product. Mechanical pencil is relative cheap and easy to obtain. This project is not limited by resources, location or facilities, and thus can be transferred to other similar courses or programs.

Mechanical pencil was presented in such a way that students would be able to define the problem and further define the problem while more information is gathered. The description of mechanical pencil is as below (see Figure 1):

Figure 1: Mechanical Pencil

Company ABC is a manufacturer of mechanical pencils. Currently they are losing market share and they want to improve their product to gain back their market position and possibly increase their profits. ABC has conducted some preliminary analysis and found out that their losses have resulted from ineffectively incorporating customer needs into their products. Their competitors have outperformed ABC in this respect. The success of this project will depend on combining a marketing function of determining the customer needs and an engineering function of decomposing and designing the mechanical pencil to meet those needs.

At each phase of product design and redesign, students are provided web-based interactive spreadsheets where they can use as templates and tools to document, collect, sort, classify and filter product data and use these data to produce a small number of feasible alternatives. For instance, in order to help students generate a component Design Structure Matrix (DSM) for mechanical pencil (see Figure 2), we provided a series of spreadsheet for students to use to create a rough geometric layout.

The structure of the course also encourages the students to utilize their creativity and critical thinking skills as well as their work experience to gain proficiency in both designing the products and becoming effective team members integrating various aspects of product development. In this course, students will work collaboratively to determine and define the problems with their choice of mechanical pencil. The redesign solutions may vary based on the information they gathered and resources that are available to them. Through designing the mechanical pencil, students are able to develop the skills and techniques required in the product development.

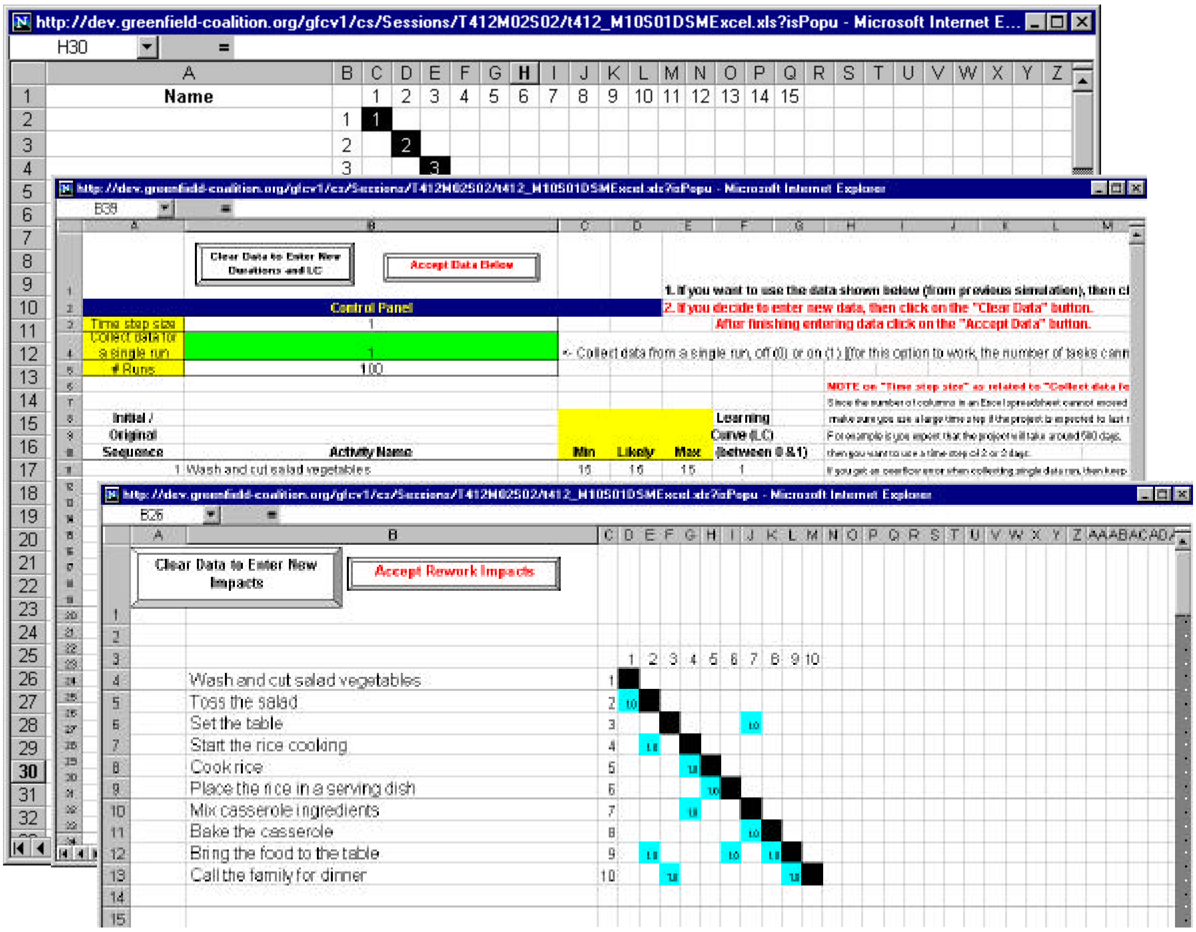

Figure 2: DSM for Mechanical Pencil

In addition to these tools provided, the course on product realization also includes brainstorming, role-play, small-group, and guided e-learning activities, as well as introductory and debriefing discussions. These activities enable students to actively seeking, evaluating, and utilizing information to further define the problem and generate solutions. Instead of instructing students what to do, instructors play a role of facilitator and guide.

Tie Rod End Case Study

In order for students to have a broader exposure to different product design and development settings, tie rod end case study was provided (see Figure 3). Redesigning tie rod end, a part for HMMWV steering system, was requested by Department of Defense (DOD). The manufacturer will no longer produce the part because the annual demand is not sufficient to warrant production in their facilities. DOD requested redesigning the substitute for the tie rod end that meets their functional specification.

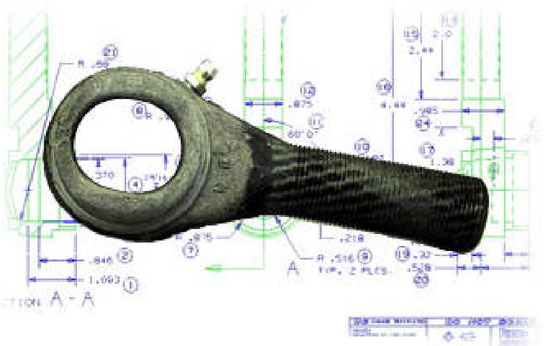

Figure 3: Tie Rod End Part

The process and resources needed for redesigning the subassembly are simulated on the web. To redesign the subassembly, students are required to assimilate a variety of data drawn from multiple sources including interviews, market surveys, blueprints, and customer specifications.

Job aids, Product Launch Roadmaps, and Peer Notes are also provided to assign students with their design and development process (see Figure 4).

DISCUSSION

The resources provided in IPR are available to education community at large. The web-based design of the IPD course allow for dissemination of the case material, course notes and class discussions to other campuses. For example, students taking the IPR course at Wayne State University can share design data with their peers at FocusHope through the course management portal. This provides a richer information base for students from both programs for common IPR case studies. The mechanical pencil redesign that was described earlier is one such example of this collaboration where interview data, design structured matrix (DSM) cluster and product architecture data have been used by classes from both institutions.

The course design approach also addresses the needs for industry's demand for better problem solvers. To ensure that the IPD processes match current practices in industry, we have incorporated the views of master performers (or experts) from Ford Motor Company and Detroit Diesel throughout the course design. The product development systems of several leading OEM and suppliers were researched to ensure that industry needs and requirements are incorporated into the course content. We reviewed the tools used by these enterprises and incorporated them into the design of the IPR templates. These templates were used by design teams of students at every stage of the product development process.

The learning environment we offered facilitates students'

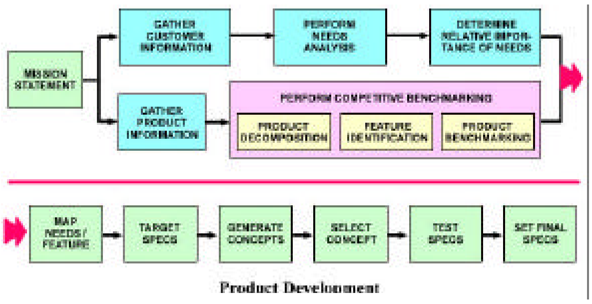

Figure 4: Product Launch Roadmap

active participation of the learning process. In addition to classroom lectures, a series of e-learning activities are available online to support IPR. These e-activities range from organizing product launch data to answering questions that require additional research outside of the classroom. Since product realization is essentially a team exercise, we have allowed extensive online interactions amongst students for sharing and analyzing product data. In such circumstances, the learning environment is enhanced by the e-activities. In addition we provide links to a range of resources both online and through further readings. Our aim is to ensure that students are aware of multiple sources of information to support the decision making process in product realization.

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