Global Product Development: Using Global Resources Effectively for a Novel Course

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Abstract

Today's engineering professionals are expected to conduct business globally, often collaborating within teams that are geographically distributed in various countries with diverse languages, business cultures and governmental regulations. This increasingly important aspect of distributed teamwork has not yet been addressed by engineering institutions. The Global Product Development course described in this paper tackles this issue by using e-technologies to create a global classroom spanning three continents and allowing global teams of students to work collaboratively to develop global products. It provides students a unique understanding of time, space, and cross-cultural barriers that need to be overcome in the new distributed workplace of global companies.

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I. Introduction

A. Globalization and Engineering Education

Mergers and acquisitions of the 90's have created a large number of multi-national corporations (MNCs) well equipped to do product development, engineering and manufacturing all around the world. The forces of globalization have been fuelled by advances in information technologies and have created a diverse and complex marketplace for consumer products. Understanding cultures and consumer needs is now even more essential for the success of any MNC and its products [1]. In such companies, product development engineers work in multidisciplinary teams, often geographically distributed in various countries with diverse languages and business cultures. The use of advanced communication and collaboration tools is a part of their daily corporate life.

Engineering institutions are keenly aware of the need to prepare future engineers for the global work environment. Global engineering programs exist in many universities and they require students to study for a semester or more in a foreign institution. Despite the cost and logistical barriers posed by having to leave campus for a full semester, the experience gained by the participating students is indeed valuable. Such programs and novel enhancements are on the rise.

This paper describes a new course — Global Product Development — that stems from the importance of a global perspective in engineering education. More specifically, the course was developed for engineering graduate students (primarily) to gain a hands-on experience in the *development of global products* as well as the *global development of products*. Both are important for future engineers and the synergies were effectively exploited in the course to provide students an understanding and appreciation of the complex environment that exists in the real world of MNCs.

B. The Global Product Development Course

Offered since Fall 2000, the Global Product Development (GPD) course uses videoconferencing to create a global classroom spanning three universities in three continents. In Fall 2000, the University of Michigan (UM), Delft University of Technology in the Netherlands, and Seoul National University (SNU) in South Korea offered the course. In Fall 2001, the University of Michigan, Seoul National University and Oxford University in England offered the course and plan to offer it again in Fall 2002.

It is important to note at the outset that the GPD course is neither a standard product development class focusing on global products, nor is it a glorified distance learning class spanning three countries. The development of this course involved much more than putting yet another course "on the Web" for students in three countries. While many courses are taught in a distributed environment using the Internet and other tools, the real value and transforming power of the Internet shows in situations where the distributed environment itself becomes an educational asset. Such is the case in the Global Product Development course. Lecturing about distributed development of products for global markets without the students experiencing it first hand would be akin to teaching freshman chemistry without any laboratory experiments.

The GPD is a unique engineering course that has been created on the "bringing people together" philosophy. It connects young minds from different parts of the globe in the context of a creative process. It is also an unprecedented cooperation by participating faculty and staff of the institutions that involves collaboration on all levels, not just lectures and semester projects but determination of curriculum, writing of case studies, etc. The importance and influence of out-of-class activities in the learning process is well documented [2]. In the GPD course, this out-of-class experience takes place both in conventional and Internet environments and we describe what steps were taken to address this.

II. The Supporting Infrastructure

A. The Global Classroom

The course lectures are held on Tuesdays and Thursdays in the "global" classroom. The lectures come from all three participating universities in real time (i.e., 8 a.m. in Ann Arbor, 1 p.m. in Oxford, and 9 p.m. in Seoul). By videoconferencing and other e-tools, three regular classrooms (in the three universities) are connected, most of the time seamlessly, to create the global classroom. A regular classroom supports a professor's lecture by enabling spontaneity, eye contact, rich interactions, visual cues, etc. In our experience, the GPD global classroom provides much of the same via technology.

Each site used Polycom Viewstation for videoconferencing. During the past two years, both ISDN and IP lines were used (selection of one over the other is based on speed and quality). ISDN provided high quality and reliable connections albeit at a high cost (using four phone lines at each location we attained a speed of 256 kbps). Internet2 proved quite effective between UM and SNU, but Oxford had problems due to firewalls.

While Polycom supports an impressive list of input sources (microphones, video cameras, VCRs, document cameras, computers), which enables sharing almost any type of material including PowerPoint slides, only one source can be active at any given time. Therefore, in GPD the Polycom is used exclusively for video and a Web-based conferencing tool provides the PowerPoint slides during lectures. Placeware Conference Center, Webex and Fusionweb (a newly developed webtool in Korea) have all been used in GPD with good results. This integrated environment of video/audio/text allowed each site in the global classroom a consistent view: powerpoint slides controlled by a lecturer who is seen by VC in two sites and in person in the third site.

Despite the occasional speed, bandwidth and network problems, the information technology infrastructure has been extremely reliable. We are quite confident that our global classroom will continue to provide an excellent environment for students each class period. See Dutta and Weilbut [3] for more details on the IT infrastructure issues related to GPD.

B. Collaborative Work Environment

Besides the lectures, the students received and submitted assignments, worked in distributed teams, communicated frequently outside the teleconferencing room, accessed course materials, etc. This was provided by Blackboard CourseInfo and Fusionweb. Both environments supported a set of necessary requirements for collaborative work including discussion boards, e-mail system, bulletin board (announcements), space for course materials, personalized Web pages, directory of participants, whiteboard (with collaborative browsing capability), chat rooms, etc. It has been documented that electronic communication across cultures presents unique challenges [4]. This is especially true for the GPD environment, and we continue to pay attention to the course design to address this issue.

For distributed product development work, there is a need to establish a collaborative computer aided design (CAD) environment. With a view towards ease of use, in the past two years GPD students were provided access to eViz and/or Alibre. Both are fairly sophisticated tool that allow collaborative development (viewing and manipulation of 3D object models from native CAD applications) in real time, over standard Internet connections. Both are provided through the ASP model, so no investment in hardware and server software was needed.

As is often said, a course overloaded with e-tools runs the risk of becoming a course about these tools, instead of the subject matter being supported by the tools. GPD clearly runs this risk and adequate staff support and preparations each year are necessary to insure e-tools learning curves and performance do not ruin the student experiences. Balancing the desire for incorporating value-added new technology with the reliability provided by older versions is a continuous challenge.

III. Course Content

In the Global Product Development course, students experience and appreciate the power of cross-cultural thought processes and collaboration in the context of a creative process — developing new products appropriate for global markets. The students in this class have come from mechanical engineering, manufacturing engineering, engineering science, industrial design, and business. The course provides students the opportunity to work in cross-cultural teams and use information technology to collaborate across space and time to create new products.

Focusing on product development for the global markets as well as developing them globally, GPD lecture topics cover a variety of issues related to global product development, engineering and manufacturing. The content of the course followed the general outline: global products and globalisation; the design process, allocation of function to components; manufacturing technologies; case studies of global products; the supply chain; and the future of manufacturing, re-cycling and re-use.

At the outset of the course, all the students assembled in Oxford University for a week to be assigned their teams and to begin the process of teambuilding and brainstorming product ideas. During this week, the lectures presented some examples of global products, with the basic ideas of what constitutes a global product. A video-conferenced lecture from a senior executive from General Motors reinforced the message on the importance of global manufacturing and how it differs from the traditional, national concepts.

The project statement called for the student teams to develop a internet-ready product. They could add the "Internet-ready" function to an existing product or develop a new internet-ready product. The product would have to use the Internet in a novel way that would add functional value to the product, so that it would satisfy an unmet need. The students were free to select either a consumer product or a business-to-business product. The products that the students designed and prototyped in Fall 2001 are shown in Table 1.

Table 1. Student Projects.

Internet-ready truck
Automated plant watering device
Automated pharmaceutical dispenser
Internet-activated door lock
Educational toy
Smart shopping assistant
Mobile phone browser for parking spaces
Remote post office

The students returned to their home countries after the weeklong meeting and began of whittling the raft of ideas down to about four feasible ideas. The students were now beginning to function as teams, using their local knowledge, technical backgrounds and skills to develop the concepts behind each product. The students presented their product ideas and progress in design reviews presentations. Following these, the professors commented on the ideas and suggested improvements and further product development ideas.

During the next four weeks, the students refined their product ideas and began to focus on the development of their prototypes. During this phase, the accompanying lectures focussed on new techniques and paradigms in manufacture as well as the analysis of case studies of global products. The case studies were developed with the help of industry (e.g., Steelcase, Kodak, Samsung, Ford) and presented by executives. This gave the students an excellent opportunity to question the people involved and to observe the cultural, historical and market forces that had driven different manufacturing economies to focus on different aspects of the products and their markets. Each lecture is followed by a brief discussion, during which students from all three locations ask questions of the presenter or offer comments on the subject. The lectures are recorded and published on a Web site soon after, for on-demand playback.

As the end of the course approached, the students' projects were reviewed once more. At this time, the product ideas were clear, the market analysis was being developed and the prototypes were taking shape. The lectures were focussing on the concerns beyond manufacture, towards the supply chain, the sustainable product and the future of manufacturing technology.

The climax of the course saw all the students gather together again, at Oxford University, to complete the development of their prototypes, prepare their final presentations and assemble their exhibition stand. The course concluded with an exhibition of all the products, to which were invited members of the local faculty and students. A Global Education Forum accompanied the exhibition. This was addressed by a speaker from Unilever who spoke about globalization issues and the need for engineering education to focus on such issues in the curriculum. The students were invited to contribute to the discussion by expressing their views on the course and how it had affected their learning experience.

IV. Impact on Student Learning and Performance

This section will describe how this course impacted student learning, in terms of the content and context of the course, but also the opportunities for enrichment of the student experience. The performance of the students will also be reviewed, from several perspectives.

A. Context

One of the main challenges in creating this course was in integrating the very different course structures and pedagogical approaches of the three universities. Seoul National and Michigan were both structured according to a semester system, with lectures starting in mid-September, and lasting for about 12 weeks through to mid-December. The lectures could be accompanied by whatever coursework or term papers were considered appropriate by the instructor. The course was then assessed by coursework, examinations or a combination of both. Team projects could easily be accommodated within this flexible structure. Students from many departments could choose to participate in the course, subject to acceptance by the instructor and the presentation of appropriate pre-requisites.

This was in great contrast with the course structure and practice at Oxford. This course was presented as part of the final year of a four-year Masters in Engineering degree. Students are permitted to choose from a limited range of courses offered by the Department of Engineering Science. Each course is assessed by an end-of-year examination, with no coursework submitted. Lectures take place during an eight week term, which runs from early October to late November. The students would have had very limited exposure to the concepts of manufacturing engineering prior to taking this course, but would have been exposed to a broad range of courses in electrical, computing and mechanical engineering. Typical Oxford lectures were 60 minutes long, happened once a week, and involved very little spontaneous dialogue between lecturer and students. At the same time as taking the courses, the Oxford students also worked on an individual project, which was assessed by a 10,000-word report at the end of the year.

Hence, the participating universities contrasted in terms of the course structures, assessment methods, attitude towards team or individual projects, length of term, skills of students taking the course and mix of student backgrounds.

This broad range of skills and backgrounds also presented challenges in delivering a course that would interest and stimulate students from such a diverse set of cultural and educational backgrounds. However, the nature of the course lent itself very well to presenting a structure that would follow the sequence of activities that are involved in the design and realisation of a global product. This structure provided a "story" on which to locate the students' learning, giving the students with backgrounds in engineering, business and design a clear role and a realistic learning opportunity. The lectures followed and supported the activities the teams were conducting in pursuit of their product development.

B. Enrichment

The enrichment of the student experience was quite unique. The special aspects of the course were: the cultural and personal experience of working in a global team; the technology required to facilitate global working and teaching; the opportunity to develop a working prototype of a useful product; and meeting the challenge of integrating mechanical, electrical, computing and internet devices that were developed in a distributed environment

During the forum discussion, the students mentioned very effectively the experience they had gained by working together as global teams. The European, North American and Far Eastern students learned a lot from solving problems together, trusting each other to deliver on time, being patient and understanding of others culture's ways of interacting and accepting and appreciating the skills and backgrounds that were brought to bear.

The effectiveness of the students work was made real through the products that were on display. This was evidenced further by the commitment and conviction with which the students spoke about their products. For the students, these products were real. They could be taken up by a company and developed for market straight away. For those who attended the exhibition, the products were so useful and convincingly presented, that you'd want to take the prototype right home and start using it.

C. Student Performance

Our pedagogical objectives were what one would normally expect from university professors, but with one extra goal. We wanted to change the way the students thought about the world. We wanted to give them a new perspective on products and equip them to think effectively about the processes involved in designing, manufacturing and delivering products to a range of markets around the world. But we also wanted them to think about how products would need to be adapted to function and sell around the world, and the logistical, technical and cultural differences to which a global team would have to be sensitive.

Students for Fall 2000 participated in an anonymous, online survey composed of twenty questions. Details are contained in Dutta and Weilbut [3]. More than 80% of respondents stated that the global team approach "added tremendous value to the course" and stated that they would participate in a similar course again. 64% rated videoconferencing as "very useful," contrary to the widely held opinion of live video as unnecessary frill that adds little value to communication. Most importantly, 100% students claimed that the course changed the way they saw themselves and/or the world afterwards.

In Fall 2001, we had informal discussions to assess the students' achievement. It was our impression that they did make significant progress. We could also see how the students developed personally over the duration of the project, many of them becoming more confident and out-going as the course and team sessions progressed.

The institutions were very supportive of the course outcome. For Oxford, however, rules had to be bent and new procedures established in order to accommodate this course. Oxford had never seen such an exhibition before, and it was a major boost to the course's standing for everyone to see the quality, creativity and technical competence of the products. Its success and innovativeness will refresh the whole approach to teaching this subject in the department, and will act as an example for the whole of the United Kingdom.

All three universities have used the course in their press briefings and several articles have been written about this course. The course, nominated jointly by Cisco Systems and SBC Communications, received the 2002 Computerworld Honors.

D. E-technologies for Enhancing Student Learning

The lessons we learned from this experience are that when the technology works well, it looks like magic, but that the students' expectations and experience of the lecturing environment still present a hurdle. These cultural gaps cannot be solved completely by technology, but effective technology is essential.

Another important lesson is that the students are resourceful and that they will find or devise the technology that works best for them. They will also teach each other and share the technology that is available out there. So, problems that we had feared did not materialise to the extent we had anticipated.

The teaching objective was to see the distributed development of an Internet-ready product. This was an ideal project, because it embodied, assumed and utilised Internet technology. The mode of delivering the course was consistent with the product that it developed. This integration of concept and output was a major source of synergy for the course, since the students could appreciate to some extent the challenges of delivering the course, since they were experiencing the same difficulties in their own teams while working through the projects.

The new objective that we can achieve with a course of this nature is to train and educate a new kind of engineer for the 21^{st} century. This will be a person with a global perspective on the world, culturally aware, environmentally literate, comfortable with manufacturing technology and the demands of the market, and capable of developing a global supply chain while knowing the technologies within his/her own facility. Such a person will have entrepreneurial skills, but technically competent enough to identify the engineering challenges their vision demands. To train engineers who can look ahead to face the challenges of the next century, we need to embrace 21^{st} century technology as the means of teaching.

As the course develops, we hope to bring in more interdisciplinary and real-world issues, e.g., develop a business plan for a new business, with a product of their design. Such an exercise could involve the whole team or a subset. Students could also be asked to take an existing product and critique its current manufacturing and marketing processes, indicating how they would amend it to enhance the global nature of the product. This could go beyond the usual business school exercise to include a more detailed assessment of the engineering input to product design, manufacturing processes and logistics.

V. Sustainability

The difficulties of developing this course and sustaining it falls into two categories: logistical and financial. Each university has its own calendar, curriculum, pedagogy preference, etc. To design a course that would be acceptable (and approved by) each university is challenge. We have done this twice now, but our long-term goals are obviously to arrive at an agreement between the participating universities that will insure that this course is offered once each year. We believe that each year under the belt gets us closer to this goal by increasing our understanding of the differences between the universities.

The financial requirements of this course are also unique and stem from the need to get the global student teams meet face to face once or twice during the semester. Such meetings are critical to the establishment of trust and bond between the team members as well as understanding the intrinsic cultural differences and technical competency within the team. The Global Product Development course is supported through the participating universities, and extraneous costs associated with a course of this nature are offset by corporate sponsorship secured separately by each institution.

VI. Summary

This course, going on its third annual offering, has been a success on several levels. Various sophisticated e-technologies have worked seamlessly together to create the global classroom and collaboration environment. Students appreciated the challenge of working in global teams in a cross-cultural environment producing novel ideas and working prototypes. Not surprisingly, all students agreed that this course provided a valuable experience and the course had changed the way they saw themselves and the world around them. Last, but not the least, the instructors and technical staff worked as a (global) team to find common ground between different educational calendars, different sets of requirements and curricula, to successfully offer the course.

The logistical and financial challenges notwithstanding, this course brings together students from three continents to work in a collaborative environment and create a new product that is culturally appropriate for a chosen market in the world. This course is realistic preparation for future engineering executives in MNCs. In addition to the technical issues, students take away a unique understanding of time, space and cross-cultural barriers that need to be overcome in the new workplace. The course provides an opportunity for students to use cultural diversity as an asset in the creation of products for the society.

It is clear that without information technology this course would not have been possible. But, information technology does not just make this course possible or enhance it. It is the tool that ensures the course's global character by creating the virtual classroom and the out-of-class collaboration environment. A lot depends on the design of such learning environments and we are reminded of John Dewey's words: "We never educate directly, but indirectly by means of the environment. Whether we permit chance environments to do the work, or whether we design environments for the purpose makes a great difference." [5]

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