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EDUCATING FOR GLOBAL PRODUCT REALIZATION ON A GLOBAL SCALE

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ABSTRACT

Three universities on three continents co-operated in teaching global product realization. The Global Product Realization (GPR) course is a highly innovative course in which virtual classrooms and workshops have been formed via ISDN lines, internet facilities and other information technological means representing the state-of-the-technology. This paper gives an insight into the background, the goals, and the implementation of the course. It also outlines the course contents, the layout, and the supporting infrastructure. The GPR course is based on three backbones: academic lectures, company case studies, and a product development project. Parallel to learning of the theoretical and practical backgrounds from academic and industry experts, the international student groups were busy with the development of a global product. It was a coffeemaker for the American, Dutch and Korean markets. The results achieved by the students were presented at the GPR Closing Workshop and Exhibition, where all participants came together to meet the media and the interested parties from academia and industry. The GPR course is a good example of a successful utilization of the opportunities offered by the latest technologies for the implementation of global design and manufacturing in a global environment.

1. INTRODUCTION

1.1. Trends and challenges

Three megatrends have direct influences on the current socio-econo-technological (SET) platform of industrial production. *Globalization* is demolishing the geographical, cultural, social, technological and economic borders. *Customization* intends to provide all goods, means, and services according to the individual needs of the human beings. *Naturalization* puts the relation of the human society and the natural environment into the center, and initiates thinking about ecological and sustainability issues of product development and use. Besides the mentioned social, industrial, economic and cultural influences, the megatrends have a profound impact on the practice of engineering designers and the education of the engineers who have to be active under this system of constraints. It raises new challenges, which can be answered properly only if we are aware of the nature of changes, clearly understand the expectations, and possess the knowledge and skills that are needed.

Actually, what are the challenges that product designers, developers, manufacturers and marketers have to take? What are the principles, rules, facts, methods, tools and pieces of knowledge that product engineers of the future need to know in order to be successful in global product realization? What are global products, and what characteristics distinguish them from conventional international, brand and local products? How to take the opportunities offered by technological developments to improve the efficiency and quality of global product realization? By what means can a company achieve global competitiveness or preserve its leading position?

In the fields of technology and knowledge, several developments support the steps towards global product realization. Availability of the supporting technology and knowledge is however just one of the ingredients. We also need the people who can employ it (van Oosten Slingeland, A., 2000). Based on the statements and questions mentioned before, it can be obvious for everybody that advancement can be expected only from innovative educational courses that specifically address these and other issues of global product realization.

1.2. Our reply to the challenges

We recognized the necessity of providing our students with knowledge about product development in a global context and improving their skills to produce global products. It stimulated us to develop a dedicated international educational course. In designing the course we took into consideration the requirements and the recommendations of the ABET 2000 document. Our aim was to let a team of geographically dislocated students learn about the theories, methods, tools and system of designing, manufacturing, distributing and using products in a global context by using the latest results of information and communication technology.

The course named Global Product Realization (GPR) was organized with the participation of three universities from three continents. The involved universities were the University of Michigan at Ann Arbor (United States of America), the Delft University of Technology (The Netherlands), and the Seoul National University (South Korea). The idea and the contents of the course was developed by three professors, namely, professor dr. Debasish Dutta of UoM, professor dr. Imre Horváth of TU Delft, and professor dr. Jongwon Kim of SNU.

The course was carried out based on interactive video-conferencing and many facilities of computer technology. To enable communication, to store the lecture materials, and to disseminate project information, a homepage with blackboard support was created. The course had a one-semester schedule, structured into five modules. The exact time schedule was adapted to the holidays in all three countries, to extra examination periods, and to other exceptions. At the end of the semester, the students and the instructors came together for a Closing Workshop and Exhibition where all participants showed the results of their projects to each other, to the media, and to the interested parties from the academia and the industry.

This paper presents the organizational and implementation details of the GPR course, which proved to be successful in (i) transferring knowledge about product development in a global context, (ii) presentation of the means that enable us to realize it, as well as (iii) development of the skills and expertise of student groups. It depicts the course contents, presents our experiences, the lessons learned, and the results reached by means of the enthusiastic contribution of the students and the instructors of the three universities.

FIGURE 1 A SNAPSHOT OF THE GPR CLASS

1.3. Professional and educational goals

The Global Product Realization course is a highly innovative course in which virtual classrooms and workshops have been formed via ISDN lines, internet facilities and other information technological means representing the state-of-the-technology. Figure 1 shows a typical classroom of the GPR course. Held in the fall semester of 2000, the course was designed to deal with a wide variety of issues related to designing, manufacture, distribution, worldwide marketing and retailing of global products by conventional or virtual enterprises. Our professional goals were as follows: (i) explaining the requirements for global products, (ii) introducing the categories and the specific characteristics of global products, (iii) providing a deep insight in what global product realization means in the practice, (iv) presenting the differences and challenges that emerge in working in geographically distributed international teams, (v) making the students acquainted with the use of video-conferencing systems, the computer tools supporting distance design collaboration, the network-based design, manufacturing and product data management systems, as well as with the emerging technologies, and, (vi) giving the students hands-on experience in designing and developing global products for several target customer groups around the world.

A definitive aim of the GPR course was to provide knowledge for the students not only about the philosophies, strategies, practical methodologies, and learnt experiences, but also about the advanced information technological infrastructure and the concrete design, manufacturing and communication tools that can be used in global product realization. The emulated virtual enterprise environment made it possible for them to work together as an international team using an arsenal of information and communication technological means. Unified computer aided design, analysis, simulation, presentation and manufacturing tools were available at each of the three locations The open-ended global product design and manufacturing problem proposed by the faculty members requested the students to apply their best knowledge, skills and intuition. It definitely raised their awareness of product functionality, performance, quality, safety, cost, environment, manufacturing considerations as well as of standards, budgeting, tariffs, laws, logistics, and so forth. Using the wide choice of systems and tools, the students not only learnt how to work with these facilities, but also became aware of the still existing limitations of the GPR technologies. By means of working in an international team real time, the students learnt how to make advantage of the versatility of their professional backgrounds and skills, and to accept and appreciate cultural differences.

1.4. Related initiatives, projects and results

The challenges for design education in the age of proliferation of the information and communication technology have been recognized more than a decade ago (Owen, C. L., 1990). Better adaptation of the curriculum to the changing needs of the economy became one of the central issues of higher education. New policies have been elaborated with a view to the rethinking, reshaping and restructuring - 3R - of academic, business and government sectors (Kozmetsky, G., 1997). The need for internationalization and globalization of academic education is an accompanying phenomenon of globalization of production and sales. Although there are examples for extramural education in various forms, the principles, the methodology and the infrastructure of interactive teaching and learning on a really global scale has not yet become a daily routine. Waldron, K. J., 1999, states that the World Wide Web has already proved very useful as an adjunct to more traditional means of presenting textbook and video materials. He also mentions that large up-front investments have to be encountered and the continuing costs also may be relatively high. Besides the investments and efforts needed to set-up and letting courses run, professional problems such as (i) finding the scheme which is in line with the objectives of the collaborating institutions and matches to the educational backgrounds of the involved students, (ii) building out the infrastructure that supports not only lecturing, but also working together irrespective of the time and cultural differences, and (iii) involving innovative principles which enable to achieve better synthesis of the related knowledge and make it possible to learn by doing, have to be solved.

Beitz, W., Helbig, D., 1997, propose various strategies for the future generation of educational systems for product developers. Bertodo, R., 1999, describes those factors that influence competitiveness in product development on a global scale. Thomson, A. et al., 1999, report on the ICON2 project, which was brought to existence to facilitate a remote design project among three Scottish universities. By the end of the nineties, several universities have made efforts to establish courses based on the opportunities offered by Internet communication, teleconferencing and/or videoconferencing.

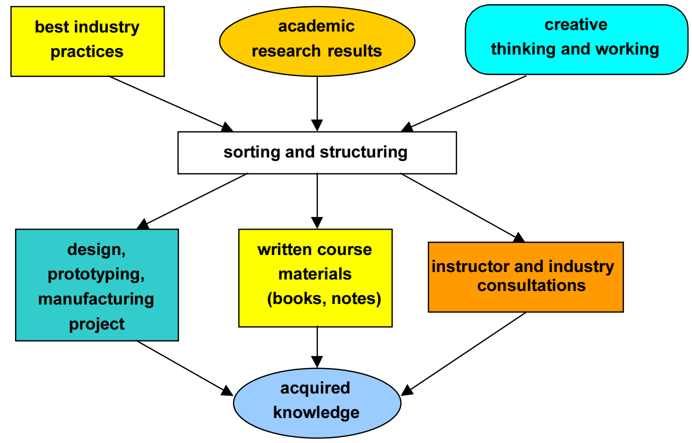

FIGURE 2 THE BACKBONES OF THE GPR COURSE

The differences between conventional classroom courses and World Wide Web-based courses have been clarified (Wallace, D. R., Mutooni, Ph., 1997). Not only the orientation of the education, but its quality and values received attention (Braham, J., 1993). Phillips, W. M., et al., 2000, address relevant issues of the new ABET 2000 criteria. Various product development, realization and manufacturing engineering courses were offered, some of them towards a better understanding of the cultural differences (Guilbeau, E. J., Pizziconi, V. B., 1998) and some of them to get experience with international co-operations.

2. COURSE OUTLINE

2.1. About the contents

The developed one-semester course offered the students a systematic introduction to, and practical experiences with the realization of global products. The education started on 7th September and ended on 22nd December 2000. The schedule of the lesson hours was adapted to the educational and examination periods, even to the holidays, of the three countries. The course was organized around three backbones, namely, academic lectures, company case studies, and student projects. (Figure 2).

The course topics were sorted into five modules. Module I of the GPR course is an introductory part focusing on the definitions, concepts and examples of global products and their realization. Distinguished scholars were contributing with comprehensive lectures. In modules II, III and IV, typically two-two company case studies from each country were presented about the views, approaches, operations and products of the concerned companies. The duration of the presentations of the company representatives were typically of 90 minutes, and were followed by so-called deepening lectures that built on selected subtopics of the case study presentations. The deepening lectures were typically of 30 minutes. Module V is the conclusive part, which gave the stage to a series of student lectures in the GPR Workshop in the University of Michigan Campus, where an Exhibition and an Educational Forum was also organized. During the semester, two intermediate Project

Review meetings and one Final Project Review Workshop were held.

2.2. Academic lectures

The academic lectures were intended to increase the awareness of the issues related to global product realization, to present the state-of-the-art, and to give an insight into the supporting methodologies and technologies. The following stage setting lectures have been presented during the course: (1) Introduction, course description, semester project and special topics (2) Corporate strategies/policies for globalization, (3) Managing competitive discontinuities, (4) Electronic collaboration and virtual teaming, (5) Properties and realization of global products, (6) Properties and examples of dedicated global products, (7) Properties and examples of platform global products, (8) Properties and examples of transformable global products, and (9) Properties and examples of smart global products. The presentations were followed by question and answer sessions. Relying on sophisticated a video conferencing hardware and software platform, the lectures were transmitted to all locations based on the H.323 protocol. With these a lively interaction with interruptions, comments, questions and discussions was achieved.

2.3. Company case studies and deepening lectures

The case studies revealed the philosophies, strategies, and approaches followed by leading international and global company, but also clarified their understanding of global products, global operation and virtual enterprises. The list of company case studies features the following presentations: (1) Conceptualization of a global product at Philips Customer Electronics (Philips, NL), (2) Detail design of a global product – a convertible helmet (Vlamboog, NL), (3) Examples for global design and development of products in Korea: DeviceNet network units and copy machines (Samsung, KR), (4) Some field experiences on global product realization (PD&E Automotive Solutions, NL), (5) The globalization of Steelcase's LEAP chair (Steelcase Corporation, USA), and (6) The global development of the Lincoln LS and Jaguar S-Type (Ford Motor Company, USA). Following the company presentations, the deepening lectures provided extra information about the most important issues that appeared in more than one case study.

The deepening lectures in Module 2 were as follows: (1) Global or local, what does the customer think?, (2) The "trinity" of design, material and processing is "holy" in product development, (3) Design for modularity and transformability, (4) Networking for global product development, (5) Virtual prototyping of products, and (6) Standardization and customization - a paradox for ever.

In Module 3, the following deepening lectures were presented: (1) Rapid prototyping of global products, (2) Design for manufacturing and assembly, (3) Trends for advanced manufacturing technologies, (4) Design for quality, (5) Evolution of manufacturing systems, and (6) Design of manufacturing system configurations.

Finally, Module 4 contained the following deepening lectures: (1) Supply chain for global operations, (2) Information management in a global enterprise, (3) Marketing by e-commerce and e-business, and (4) International patents.

FIGURE 3 THE 'GLOBAL PRODUCT' AS SEEN BY ONE GROUP OF STUDENTS

2.4. Students' term projects

The students were assigned a semester project aiming at a global product: a coffeemaker for the American, Dutch and Korean market. The task covered designing, developing and physical prototyping the coffee dispenser (Figure 3). The academic and industry lectures provided the students with the necessary theoretical, methodical, technical and practical background knowledge. Six students, two from each university, formed a group and worked together on a global product realization project. The students could experiment with the cultural differences and the differences in the professional backgrounds and interests. Two instructors supported their work throughout the semester.

The groups made extensive use of the available communication channels, video- and network conferencing

FIGURE 4 TOWARDS A GLOBAL PRODUCT

software, blackboard and chat means, file transfer tools, CAD/CAE/CAM software, physical concept modeling, rapid prototyping and advanced manufacturing equipment (Figure 4).

The very first project meetings were dedicated to help the students get acquainted with and get closer to each other. As mentioned earlier, the assessment of the project happened two times during the semester, completed with a final project demonstration and exhibition. The results of the activities of the groups were finally presented at the GPR Workshop in the University of Michigan campus, where the students and the instructors came together to meet and to work face-to-face at the end of the semester. The project deliverables were (i) verbal presentations, (ii) written project reports, (iii) posters for the exhibition, and (iv) various physical models (mock-ups, partially working models, and prototypes of the products and their subsystems, respectively).

3. ABOUT GLOBAL PRODUCTS

3.1. Definition of global products

It is evident that *global products* are those products, which are produced and marketed internationally, as opposed to those ones, which are produced locally, and mainly for the local market. The products marketed worldwide must have everywhere attractive and/or locally distinctive product characteristics. However, not all internationally marketed products can be considered global products, even if they have global characteristics. There is a fundamental dilemma related to the notion of global products. The roots of the dilemma are in that several non-global products may show global properties, and the principles of distinction have not yet been clarified. The dilemma exists also in the real life, namely, in defining the products and characteristics that will be appreciated by a sufficiently large group of customers and in finding ways to design and produce products to the very specific needs of individuals in different regions of the world. All these considerations straightforwardly lead us to the necessity of a pragmatic definition of a global product. It is considered an industrially produced artifact, which (a) is intentionally designed to manifest as a global product, (b) can be marketed in sufficient large quantities with profit world wide, (c) owns enough specific global characteristics that are appreciated everywhere the product is marketed, and (d) is produced in a global organization by global technologies.

The academic lectures, company case studies and practical experiences clarified for the students that products intended to obtain global appreciation do need to have properties and/or features at least in the following six generic classes of characteristics: (a) functional, (b) aesthetic, (c) ergonomics, (d) technology, (e) sustainability and (f) marketing. The most important aspect of solving the dilemma between customization and generalization is choosing the extent to which a product should be tailored to the target customer. This can be done in various forms based on the generic classes of global products. Even if the proper choice is made for the category of the product, issues such as how to (a) tailor the product to customers' needs, (b) fulfil local standards and legal codes, and (c) achieve the most effective manufacturing on a global scale, have to be answered.

3.2. Categories of global products

There are several possibilities of introducing classifications or taxonomies over global products. From the many possibilities, we presented two for the students that gave a platform for our discussions. One of the two classifications was according to the manifestation of global products, which allowed us to distinguish between (i) investment products, (ii) consumer durables, (iii) software products, (iv) personal belongings, and (v) service products. The other way of classification was the philosophy followed in designing of global products (that also had to do with the way of implementation). From this aspect, we identified (a) dedicated, (b) platform, (c) transformable (d) smart, and (e) hybrid global products.

During the development of global products, a decision has to be made to what extent an order from a (global) customer has to be taken into consideration in the company processes. The above-mentioned five categories are alternative solution frameworks in which the customers' expectations for global products can be put into functions, forms, materials and characteristics. This way, the companies producing global products can shift from the conventional forecast driven production to customer order driven production.

3.3. Dedicated global products

The global products belonging to this class are produced in custom variations, tailored to, and distributed according to the observed local preferences. Thus, exclusively the manufacturer takes care of customization of these products. This is the classical solution for geographically tailored products. The technical solutions of the product reflect the local preferences and conditions (e.g. whether fueled by electricity, gas, oil, coke or wood, as available locally). Furthermore, the products follow the local standards and their appearance reflects the local culture.

3.4. Platform global products

These global products are built around some permanent core units, or some invariant functional components, by using a set of variant components according to particular requests. Customization of these products typically belongs to the responsibility of the manufacturer, but in certain cases further customization by the user is also possible. Nowadays, this philosophy is spreading very rapidly in the car manufacturing industry. For instance, different makes of cars (under different brand names) are built by using the same frames or chassis elements.

3.5. Transformable global products

The set of components forming the transformable global products can be restructured into configurations that match up the local needs. The manufacturer of these products provides opportunities for customization by applying principles of, e.g. design for modularity and for multi-functionality, but customization according to the needs of the actual application, the personal preferences, or the environmental considerations is expected from the end user. Certain sport goods are the best examples. Depending on the goal of the physical training, various configurations can be put together from the marketed set of the product components. The actual set up can be fine tuned to the movement, force and speed requested by the user. Transformability can extend the useful life of the products.

3.6. Smart global products

The main difference between the other classes and this class of global products is in the capability of achieving a certain level of self/adaptation. That is, these products are designed and implemented in such a way that they adapt themselves to the varying end users and to their needs based on setting, teaching, learning and/or reasoning. A personal care taker system can be mentioned as a typical example for this solution. After the daily settings and the control from the user, the system adjusts itself, for instance, to the wake up customs of the user. The functionality of the product can be upgraded by replacing the embedded firmware and/or software components. Enhancement and upgrading lend themselves to a longer useful life of the global products.

4. ABOUT VIRTUAL ENTERPRISES

4.1. The concept of virtual enterprises

The multinational companies are known to do business in a variety of international markets, but may pursue different types of multi-domestic or international strategy in different cases. Towards globalization, companies typically involve local and/or international subcontractors to extend their capacities and to proliferate geographically without further investments. What is important here is that, although the company is operating on more than one market at the same time, it treats all these markets as a domestic market. Competition is dealt with in each country on a stand-alone basis. At an even higher level of industrial and commercial escalation, products are produced at different geographical locations with international subcontractors and the company markets these products not only in the country of fabrication, but also in other countries. Such a globally operating company has distribution systems in the key foreign markets that enable cross-subsidization, international retaliation and world scale volumes.

The notion of the virtual enterprise grew out of the global companies, and adopted new philosophy in terms of the strategy of operation, geographical collaboration and providing resources. A virtual enterprise is an organic (holistic) combination of functional/structural components. A VE is typically nurturing a culture of innovation together with capturing and harnessing skills and expertise. It makes the best use of expertise of outsiders to plug gaps in thinking about the needed or challenging products. The adaptive organization structure results in a dynamic enterprise that responds promptly to new problems and opportunities as they arise.

One of the aims of the course was to clarify the concept of a virtual enterprise (VE) and let the students get experience with some elements of a virtual enterprise (which, in this case, was emulated within the academic partners). The notion of virtual enterprise has been introduced as a decentralized dynamic network with cooperation brokers stimulating the cooperation through servicing. It was made clear that a VE needs advanced production facilities, effective communication infrastructure, and logistics and control to achieve a well-synchronized behavior of the interacting (real or virtual) companies. The resources are the admissible variables of the VE configuration. Real time monitoring of the virtual enterprises needs integration of information models ranging from a geographically distributed site modeling to a shop floor level modeling.

4.2. The necessities to operate as a virtual enterprise

According to our understanding, global is more than just being international. Global product realization assumes a company is active on four intertwined activity fields, namely:

- Development of product policies
- Creation of geographical strategies
- Development of the technological infrastructure
- Effectuate organization and management

Activities in the field of product policies cover (a) development of product-market-technology (PMT) plans, (b) generating innovative ideas for global products, (c) development of new product introduction plans, (d) sustainable development of global products, (e) increasing standardization of products, (f) increasing customization of products, and (g) increasing the modularity of products/families.

Activities related to creation of geographical strategies are (a) political, economic and social analyses of the target environments, (b) specification of locations for development centers, (c) elaboration of distribution policies and strategies, (d) measuring the performance and the impact, (e) acquisition of requested capacities, (f) allocation plan for production resources, and (g) managing human resources.

Development of the technological infrastructure concerns (a) implementation of convertible manufacturing lines, (b) building multi-functional knowledge bases, (c) establishment of multi-channel communication networks, (d) interfacing

FIGURE 5 THE VIEWSTATION IN USE IN A STUDENT SESSION

heterogeneous hardware and software systems, and (e) advancement in knowledge elicitation and processing.

Organization tasks include (a) introduction of project oriented thinking and working, (b) decomposition of the activities on enterprise, program, project and task levels, (c) distribution of the business function in the target region, (d) systematization and proliferation of services, and (e) unceasing progress towards fully virtual company operation and management.

4.3. The information technological infrastructure used by the GPR students

To technically support the student projects, a multi-systems information technological infrastructure of a virtual enterprise has been emulated and used for the classrooms. The audio/video communication was based on the two double ISDN lines, with a maximum bandwidth of 256 Kbit/s. One of the universities made the simultaneous three-point conferencing available, providing the technical possibility to involve the participants at the three locations in interactive lectures. The used systems were (a) Viewstation, (b) Placeware, (c) Web-site with blackboard, (d) Net-meeting, (e) CAD, CAE, CAPP, and CAM packages, (f) e-Vis system and (g) office documentation and administration packages. At each location, to establish video and audio connection with the partner universities, the Viewstation video conferencing system was used (Figure 5). This system used four ISDN lines parallel, and applied the H.320 protocol to communicate MPEG compressed video with a rate of up to 30 frames per second. The system is able to receive video input from three selectable sources, together with high quality audio from an external microphone. The system takes care of suppressing echo and reducing the ambient noise. These proved to be very important due to the extreme geographical distances.

The Placeware software was used to communicate PowerPoint presentation slides and computer screen contents of the lecturers. It made it possible for the participants to see the animated materials at the three locations, to record the presentations (slideshow included), and enabled the technical support staff to communicate by means of chat-windows without interrupting the lectures. The slides were also communicated over the Internet. Each location was equipped with facilities to project visual images on a large screen. Two cameras were used to show the lecturer and the audience simultaneously (Figure 6). Placeware also enabled to remotely assist the lecturer to select slide(sets), pointing at items, and annotating slides. Switching to external locations, and importing external demonstration material were possible via a low speed modem connection too. During project and lecture presentations, a hardware device called Mimio was used. It converts a normal whiteboard into an electronic one, making it possible to send a vector-based image of the write-up on the whiteboard electronically to the other parties.

FIGURE 6 VIEWING THE LECTURER AND THE AUDIENCE SIMULTANEOUSLY

4.4. Virtual team communication and file exchange

For presence awareness, AOL messenger, and ICQ tools were used. These made it possible for the students and the instructors working on the same project to monitor the availability of the other members of the group at the remote locations. The course and project administration and management, as well as the communication and assessment were organized through the Blackboard system. Actually, the services of the Delft University Blackboard system were used for the above-mentioned functions, including inventory and transfer of course documents and other information carriers. It provided the students with basic communication tools, like additional e-mail, chat-rooms, whiteboard, sketchpad, file exchange, archiving of files and scheduling facilities. For graphical work, the students used packages such as CorelDraw, Adobe Illustrator, Adobe Photoshop. Since some students preferred hand made sketches, they were scanned and electronically transferred to discuss and work with.

The students made extensive use not only of office documentation software, but also of design, analysis and simulation systems. Throughout the project they were supposed to develop 3D models, and had to communicate the part and assembly files, as well as the specific application files to their group-mates. The models generated in Pro-Engineer or in SolidWorks were stored only at one location, but were available for access from all locations. Effective manipulation and presentation of the 3D models and assemblies were supported by the e-Vis software and data repository services. Hence, it was possible to use 3D models, or rather complex assemblies in discussing product development problems. Providing slower communication on the computer network, the NetMeeting software was used as a background support. It provided facilities for application sharing among all participants. Throughout the course, the videoconferencing sessions, the e-mailing, the chat sessions, and the whiteboard sessions were archived, in order to make them available for a follow-up research (analysis and evaluation) concerning both the communication and the evolution of the design projects.

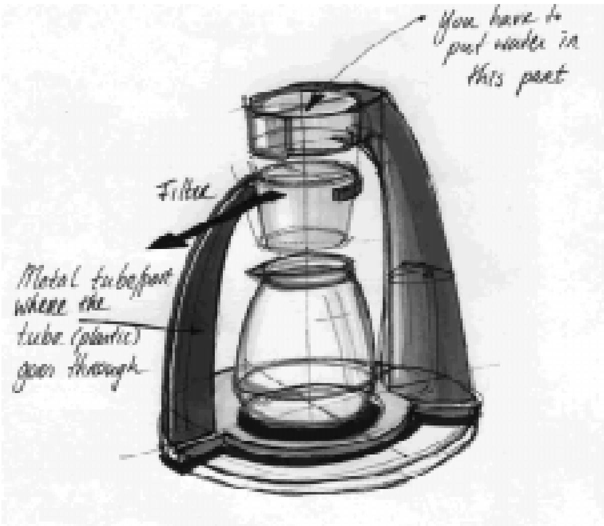

FIGURE 7 LINE SKETCH OF A FIRST CONCEPT (1)

FIGURE 9 A COLOUR SHADED CONCEPT

4.5. Working in an emulated virtual enterprise

A global product design project was assigned to each group of students, who were supposed to work on it parallel to the lectures. A fictitious global company, called Morning Coffee Inc., was formed based on an existing Canadian company, and the students were requested to develop a coffee maker. The product was aimed at a global market, including North America, Holland and South Korea. Groups of six students, consisting of two-two students from each university, were formed to simulate a real international developer team. Every team had one or two instructors/mentors from the three universities. The instructors monitored the progress of the project, and contributed to the success with their expertise and general guidance. Apart from the facts that the students lived in various countries, including Norway, India, Mexico, and of course, the United States of America, the Netherlands and South Korea, and were previously educated in a variety of countries and cultures, excellent collaboration could be observed. The students were educated mainly in four disciplines: Industrial Design Engineering, Mechanical engineering, Manufacturing Engineering and Management and Business Administration.

The global setting of the design project came not only from the diversity of the project team members, but also from the fact that it was needed to manage with the extreme large time differences. As it is known, the time zone difference is 7 hours between Seoul and Delft, and 6 hours between Delft and Ann Arbor, running up to 13 hours in total. Larger time difference is very difficult to be handled in a regular course. The target markets were supposed to be demanding, and the countries of manufacturing to be technologically advanced. Hence, the students had to consider several learnt aspects of global product realization to come up with solution proposals for these

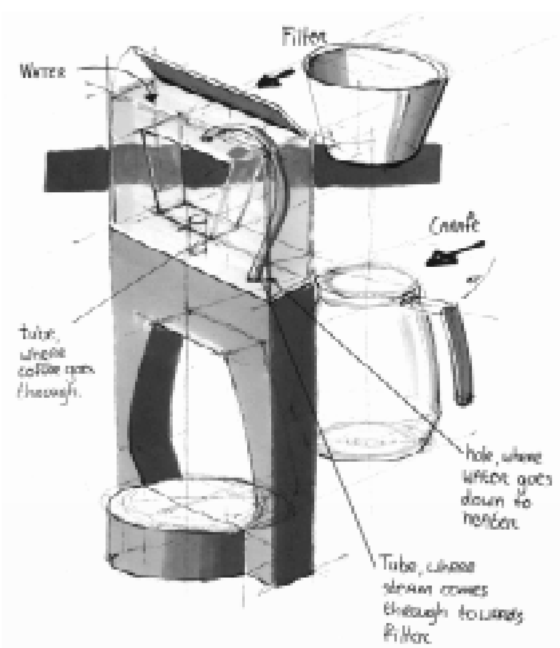

FIGURE 8 LINE SKETCH A FIRST CONCEPT (2)

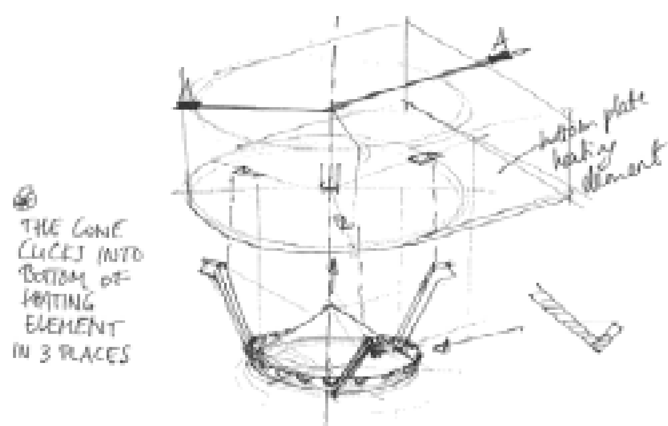

FIGURE 10 DEVELOPMENT OF A TECHNICAL SOLUTION BY LINE SKETCHING

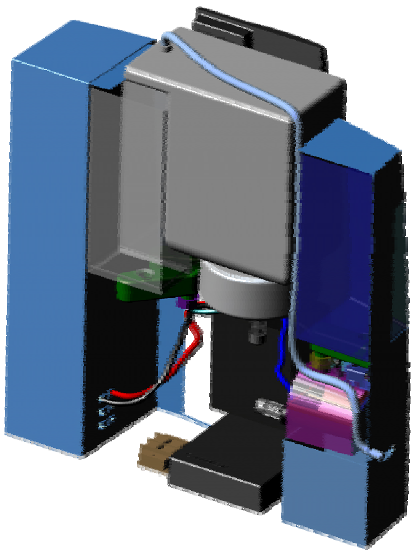

FIGURE 11 AN ASSEMBLY MODEL FOR ARRANGEMENT OF CONTROLS

specific coffeemakers. There were two progress review sessions organized in the course of the project, one after the conceptualization phase, and one after the detail design phase. The final presentation, exhibition and assessment of the project took place at the Closing Workshop and Exhibition.

5. COURSE OUTCOMES AND CONCLUSIONS

5.1. Results of the product development project

Our aim was to improve the core competencies of our students in global product realization. We intended to teach and train them to understand the processes and methods of, and get

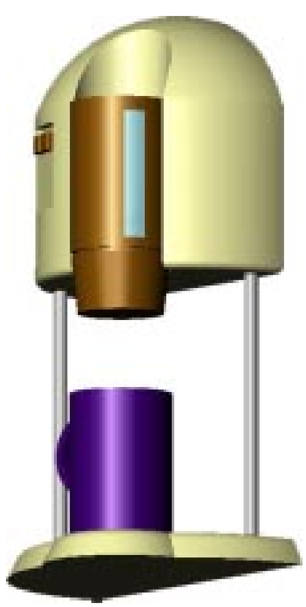

FIGURE 12 AN ASSEMBLY MODEL FOR COLOR STUDY

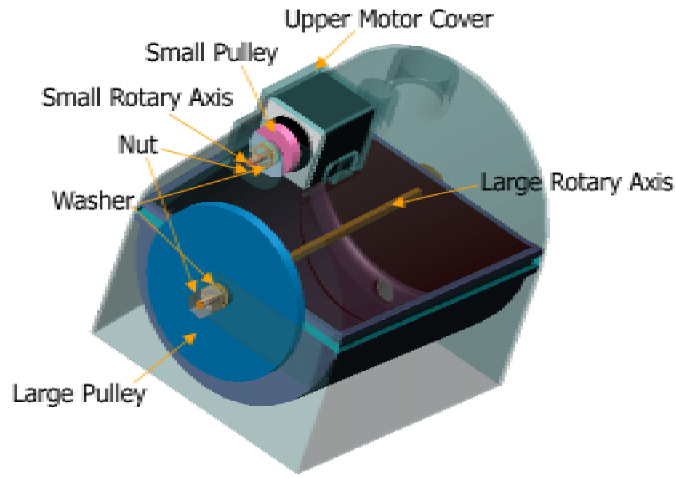

FIGURE 13 AN ANNOTATED ASSEMBLY MODEL TO SUPPORT ASSEMBLING

hold of experience with conceptualization, embodying, simulation and fabrication of global products. The vehicle was the term project which was intended to guide the students through the issues of market research, product definition, conceptual design, detailing, preparation for manufacturing, prototyping and product analysis. Rather than attributing extreme importance to the quality of the products designed by the students, we considered the comprehension of the philosophy and the process of global product realization more important. In the remained part of this paper, there is no possibility to discuss the eight student projects in detail. Nevertheless, the results produced in the above-mentioned phases of the global product realization process may give an insight in the depth and results of the student work.

After the market research, the students typically started to put down their ideas about the overall concept and manifestations of the 'global' coffeemakers by sketching. Most of them insisted on conventional hand sketching, and only an insignificant minority used CAD tools from the very beginning. They actually produced sketchy drawings. Figures 7 and 8

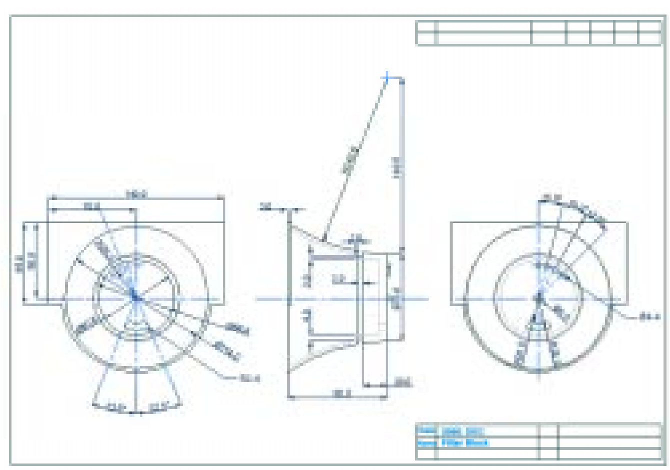

FIGURE 14 PART DRAWING FOR MANUFACTURING PLANNING

FIGURE 15 PROTOTYPES OF THE COMPONENTS OF THE COFFEE MAKER FROM VARIOUS MATERIALS

show two examples of the line sketches from two groups.

The students produced color-shaded sketches to elaborate on the appearance of the conceptualized product (Figure 9). They also favored to use sketching in detailing the parts and the connections of parts (Figure 10).

For the final geometric design of the parts and for assembly modeling of the products they typically used computer aided design systems. Figure 11 shows an assembly model, which was created to arrange the control elements. Figure 12 shows an assembly which was used for color study and for checking the global image raised by the product. In Figure 13 an assembly model can be seen which has been developed with the purpose of supporting assembling.

To communicate the geometric information for manufacturing process planning that was done by other students in the group, the students either used 3D geometric models of the parts, or conventional technical drawings (Figure 14).

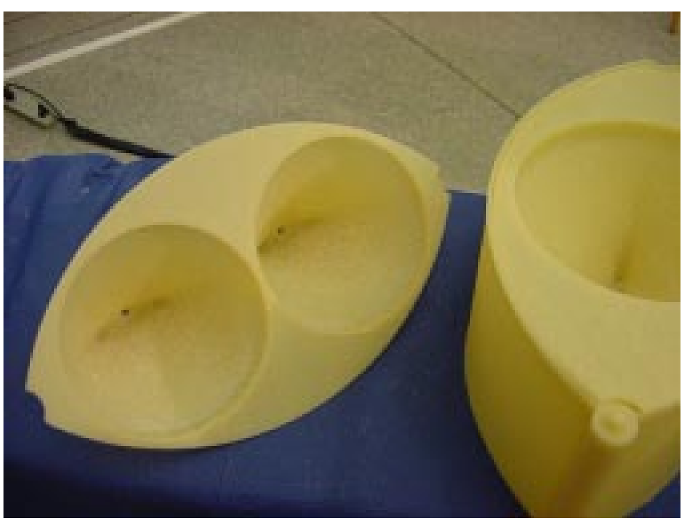

FIGURE 16 VARIOUS FUNCTIONAL ELEMENTS BY RAPID PROTOTYPING

To make the models tangible, to check the appearance and the functionality, the students created a wide variety of physical concept models and advance prototypes. High-density plastic foams, cardboard, wood and light metal materials were used for mock-up making or physical modeling. Commercialized equipment and machine tools were used for rapid prototyping and part manufacturing. Figure 15 shows a prototype of a coffeemaker, whose parts were produced by various rapid prototyping technologies and materials. Figure 16 shows a physical model of a coffee brewer unit prototyped into wax.

5.2. Educational experiences with the course

Below we discuss our most important experiences and conclusions relating product context, communication and using the GPR infrastructure.

In the interpersonal communication we observed that the language barriers were more influential in speaking than in writing. It was easier for most teams to effectively communicate by means of combinations or alternations of e-mails, chat-sessions, and document exchange, but lecturing and asking questions promptly caused problems several times in videoconferencing. In general, the Dutch and American team members had a good command of English, while Korean members, otherwise having enough competence in English, where somewhat caught up by the Asian English pronunciation in the virtual environment. Some teams had difficulties building the trust needed for effective co-operation. Sometimes, double-checking was the only means to find out if the proper understanding was reached in terms of the expected results of subtasks accomplished at the other side of the ocean.

FIGURE 17 A GLOBAL PRODUCT ON SHOW

Achieving true global characteristics of the product was the biggest challenge for the student groups. Some of them were more successful than the others in finding out what makes their product a genuine global product, Behind the success was the careful selection of customers, combining the most relevant product features, and choosing the most advantageous technological solutions. The difference in the background knowledge, skills and expertise of the students from the various Universities was easily traceable in their contributions to the project. Some students were excellent in reasoning about the markets, other conceptualized and designed very well, and the others showed their strengths in prototyping and manufacturing (Figure 17).

Although, top-of-the-category equipment was available for the three Universities, there were quite a large number of technical problems to be solved during the course. The Internet communication proved to be impractical in certain daily periods due to the overuse of the network. In general, the reliability of the ISDN lines was good, but certain cases it was simply impossible to call and establish connection to the overseas countries. What was a surprise for the technical support personnel was that they had many more problems with the quality of the sound, than of the pictures. The students could master themselves in using the audio-visual communication infrastructure in a relatively short time. They seemingly enjoyed the new opportunities and devoted themselves with enthusiasm to the success of the GPR course. Special thanks go to them for this devotion.

5.3. Conclusions

In this paper we presented our international course on Global Product Realization, in which students were given the theoretical and practical knowledge for designing, manufacturing, and marketing of global products. With all the hardware, software and brainware that could be incorporated in the Global Product Realization course we aspired to show the students what effects globalization, customization and naturalization have on products. We also wanted to make it clear what the so-called global products are and what properties they are supposed to have. Our intention was to deal with the issues relating global design, manufacturing, distribution and marketing of almost individually customized products in a comprehensive way. Each student obtained an overview on global product realization, and could develop his/her skills throughout the stages of market analysis, conceptualization, detail design, fabrication and presentation. By participating in one international team, they successfully solved the product realization assignment and collected experiences with global teamwork in a simulated virtual enterprise.

6. ACKNOWLEDGMENT

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