Hands-on Design and Virtue Experiment Training in Medical Mechtronics

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ABSTRACT: *Medical mechantronics (MM) is a newly designed multidisciplinary study program in response to the urgent needs for training engineering students with medical modality development skills in Taiwan. Chang Gung University (Taiwan) offers a master degree program in medical mechatronics. This program is designed to accept engineering and non-engineering degree students with interdisciplinary curriculum to expose students with diverse techniques (e.g. domain knowledge, hands-on skills, teamwork attitude, and creative thinking). All enrolled students are encouraged to participate a hands-on design project and virtue product development experiment during their study. This paper describes the training protocol of student hands-on design project and virtue product development experiment. The activities in the hands-on design project includes conceptual design, engineering analysis, interdisciplinary work team, progress report and presentation, literature and patent search, scientific / research methodology, and final product demonstration. The virtue product development experiment includes virtue design, virtue analysis, virtue manufacturing and virtue assembly for the hands-on designed prototype. A student hands-on design project entitled "design of a transformable driver seat / wheelchair automatic lifting system " completed in one semester is presented in detailed. The work consists of system requirement analysis using Quality Functional Deployment (QFD) technique, establish system design specification based on House of Quality (HoQ) method, perform conceptual mechanism design utilizes TechOptimizer, construct 3D computer model using Solid Works package, simulate mechanism motion with working model software, perform structural analysis using finite element analysis package, and finally construct a prototype for functional verification.*

1 INTRODUCTION

This paper proposes the Taiwan's education experience on the student hand-on design and virtue product development experiment in the area of medical mechatronics. Since 2001, a new master degree program in medical mechatronics was established in Chang Gung University, Taiwan. This program is designed to accept engineering and non-engineering degree students with interdisciplinary curriculum to expose students with diverse techniques. By emphasing the deign of medical mechatronics system, all enrolled students are encouraged to participate a hands-on design project and virtue product development experiment during their study. In addition, those hands-on design projects were selected and recommended to participate the annual student design competition sponsored by the medical mechatronics education resource center (MMERC) [1], Ministry of Education (MOE) [2-4] in Taiwan.

This paper describes a case study of student hands-on design and virtue product development experiments. The activities in the hands-on design project with virtue product development experiments includes system requirement assessment, patent search, conceptual design, engineering analysis, prototype development. The key idea of this student hands-on design project is based on an on-line web-connected virtue product development engineering experiments. The objectives of the virtue product development experiment focus not only on developing the medical mechatronic systems in a manner of integrating the theory and engineering practice, but also on encouraging the students to work effectively with various design softwares. Currently we have hardwares and softwares in CAD, in FEA, in CAE and in RP that are operable from the Internet. These are controlled either by remote control panels with direct Internet connections. A student hands-on design project entitled "design of a transformable driver seat / wheelchair automatic lifting system " completed in one semester is presented in detailed.

2 MEDICAL MECHATRONICS EDUCATION IN CHANG GUNG UNIVERSITY

Chang Gung University is a private university located in Taoyuan Taiwan. This university was established in April 1987 as Chang Gung Medical College. The engineering school was start in 1993. The university currently consist of the college of medicine, college of engineering, and college of managment. In order to train students who are well-versed in the both theory and practice, Chang Gung has instituted an extracurricular practicum program with Chang Gung Memorial Hospitals. The master degree program in Medical Mechatronics was established in 1993 as a vehicle for research and instruction combined the area of mechanical engineering and clinical medicine. By coorporated with MMERC (sponsored under the MOE, Taiwan), the teaching materials, learning planning, and international workshop of the medical mechatronics education are designed. In addition, the innovative design course combined with student hand-on design and virtue product development experimenr of the medical mechatronics education was developed.

3 STUDENT HANDS-ON DESIGN PROJECT

The student hand-on design project for medical modality development is one of the most emophasis course in our program. In Taiwan, the researches on he development of the medical mechatronics systems are not popular among the industries and universities [5]. The interested students may be suffered from the unreachable medical and clinical domain knowledge. Therefore, we encourge student to select a hand-on design project with practical problems provide by medical staff or local medical device venders. We also established an university-industry team cooperation product design training mechanism. The topics of student hands-on projects are come from real clinical needs from interested parties (e.g. medical staff in the hospital or medical device industies). The interested parties are encouraged to post their problems or requirements and consequently look for candidated students. Then, the professors can cooperate with the interested party and advise their students to participate as a problem-solving design project. Such a training mechanism is not only beneficial to the participated students and teachers, but also to the interested parties such as medical device industries. Although hands-on design experiences are important that reinforce theoretical concepts and provide an experiential learning process for product development, in many cases the self-paced, discovery aspect of the experiment is completely lost. Therefore, the student hands-on design project combined with a series of virtue product development experiments was proposed for enabling the student exercise their hands-on design procedure on web.

4 VIRTUE PRODUCT DEVELOPMENT EXPERIMENT

For several years before the Internet blossomed, we taught engineering design and product development course at the Chang Gung University(CGU) with individualized CAD/CAE/CAM/RE/RP/RT (3C/3R) equipments and softwares. With these equipments students sat in front of computers in the design laboratory and conduced a range of computer simulation and experiments. The experiments were for computer-aided-design , finite element analysis, etc. In 2003, we added the virtue experimental capability to conduct product development course via the Web. The experiments can be run at any time (24 hours a day, 7 days a week) from anyplace that a student has Internet access. Students could design and conduct experiments with the real equipment in the laboratory by specifying the experiment on a Web form and submitting the request for the experiment to be conducted. When the experiment was conducted, the computer collected the data and plotted the graphs of the performance. The student then could retrieve this data via a browser and complete the analysis of it. The experiments are run as "batch" experiments. That is, the experiment is run after the Web server at CGU has received the request. The experiments are run first-come, first-served. This has been a successful model that we are still using today. We now have added another method of remote operation. Using a remote operating panel for rapid prototyping machine, students can control equipment in real time. This is still first-come, first-serve, however, if a student is running and experiment from his or her computer, other students can connect to the server and observe the operation as the first student is conducting the experiment.

5 CASE REPORT OF STUDENT HANDS-ON PROJECT- TRANSFORMABLE DRIVER SEAT / WHEELCHAIR AUTOMATIC LIFTING SYSTEM

In this paper, a student hands-on project for designing a transformable driver seat / wheelchair automatic lifting system will be used as an example to demostrate the virtue product development training mechanism. The motivation of this project is that most disabled person relies on wheelchair for mobility due to their physical impairment. However, most wheelchairs are designed for short distance mobility only. When a long distance travel is needed, they have to rely on other people's help to transfer from wheelchair to automobile as the lifting device in the automobiles is not available. This situation not only limits their independency on daily activity, but also requires the manpower of caregiver which might increase the possibility on secondary injury if there is an improper handle. In addition, the storage in the car is another burden. To overcome the transfer barrier for disabled , this project is to design and develop "a transformable driver seat / wheelchair automatic lifting system". Quality Functional Deployment (QFD) technique, House of Quality (HoQ) method to establish system design specification, TechOptimizer to perform conceptual mechanism design, 3D computer modelling using Solid Works package, mechanism motion simulation with Working Model software, structural analysis with finite element package, and prototype construction for functional verification are all implemented in this research work. The main functions of this system includes driver seat / wheelchair rotation, driver seat / wheelchair lifting, driver seat / wheelchair roller folding, and driver seat / wheelchair latching etc. The driver seat / wheelchair rotation function is designed by taking the idea of eccentric rotational mechanism driven by electric actuator to reorient driver seat before moving down from automobile. Single actuator with dual parallel four-bar linkages for up and down movement between ground level and car seat level is designed for the driver seat / wheelchair lifting mechanism. The driver seat / wheelchair folding function is implemented with six-linkage mechanism for wheelchair roller folding and unfolding. Currently, the prototype of the system has been constructed and the functional tests were verified. The patent application has been filed.

6 OPERATIONAL ARCHITECTURE OF THE VIRTUE PRODUCT DEVELOPMENT EXPERIMENT (VPDE)

In order to achieve the sharing of distributed product development resources, the virtual product design experiment architecture is proposed as shown in Figure 1. A distributed product development resources network was proposed to construct the virtual product development experimentation (VPDE). In this work, the VNC (Virtual Network Computing) wais used to connect the remote computers that have installed the corresponding product design / development experimental software such as the QFD, TechOptimizer, Knowledgist, Solidworks, AutoCAD, PowerMILL, etc. In this manner, the client user can use the VNC network to utilize the product design software components through the network. Meanwhile, the product design data can be delivered using the FTP (file transfer protocol). In addition to the VNC product design virtual network, the virtual manufacturing of product components can also be achieved using the rapid prototyping (RP) machine. For this portion, the web camera was used in cooperation with the Microsoft Net Meeting software to monitor the production status of the product components. Therefore, based on the proposed VPDE network, the students can reach a set of product design software components and hardware machines at a location in terms of switching the product design software resource server computers. Consequently, the training effects of using the VPDE can be significantly improved.

7 STEPWISE FUNCTIONS OF VPDE

The main control screen of the virtue product development experimental system is shown in Figure 2. In the center portion of the screen, the suggested product design and development procedure and associated design software are displayed. The touch buttons for accessing each design software are shown in the left side of the screen. Figure 3 demonstrates the analysis of house of quality using in-house developed Quality Function Deployment (QFD) technique. After completing the system requirement assessment, conceptual design using Techoptimizer and AutoCAD software is suggested. Figure 4a shows the technological prediction functions of the Techoptimizer. In this design project, student selected " Dynamization trend" to illustrate the various concepts in designing steering wheel shart. Following that,

three possible conceptual design options of wheel folding mechanism are drawn using AutoCAD package. To evaluate those design options, patent search and analysis using " Knowledgist" software is proposed. As shown in Figure 5, the left part of the screen list existed patents related to car-seat and wheelchair. After the patent document is selected, the detailed information of that patent will be displayed. Figure 6a shows the isometric and dimensioned drawings of student designed chair using Solidworks. With the same software, the kinematic motion simulation of this wheelchair lifting device can be performed. In the same time, structural analysis using finite element method and assembly analysis / value engineering analysis are exercised in Solidworks as shown in Figure 7. After that, the cutting tool path simulation for machined parts can be executed on the computer (Figure 9). Finally, the rapid prototyping machine can be accessed remotely through interent for key compount evaluation. The control panel and picture of the rapid prototyping machine (3D system, USA) are shown in Figure 10a and Figure 10b. The final product of his student hands-on-design project is shown in Figure 11.

8 ADVANTAGES OF WEB-BASED VIRTUE PRODUCT DEVELOPMENT EXPERIMENTS

As described in this paper, the proposed web-based virtue product development experiments has been successfully implemented in student hands-on design project. Further development on human interface design will be proposed. For a successful virtue product development experimental system, we envision that:

1. Students will have access to on-line computer experiments with a variety of design softwares
2. Students will be able to easily design and conduct experiments from remote sites (i.e. home, dorm, computer lab or office)
3. Students will be able to share design results on-line with instructor or team members
4. Students will be able to easily use on-line labs for assignments outside of the classroom.

8 CONCLUSION

In this paper, the student hand-on design course combined with virtue product development experiments were established for the design of medical mechatronic systems is described. Virtual experiments on design softwares and papid prototyping machine can make a significant contribution in preparing students for mastering the design and the actual physical laboratory procedures. With the virtue product development experiments, the students working in a team can share results on their experiments. In addition, students can share results with instructors and ask questions about the results. When an experiment progresses, periodic response profiles are constructed and posted on the server. Finally, a student hands-on design project entitled "design of a transformable driver seat / wheelchair automatic lifting system " completed in one semester is presented to demonstrated the stepwise virtue product experiments in detailed.

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REFERENCES

http://me.cgu.edu.tw/mmerc/Template/en/index1.htm.

http://www.edu.tw/

http://www.handson.org.tw/eng_handson.htm

KUO, C.H. LEE, M.Y., *Student Hand-on Competition in the Design of Medical Mechatronic Systems - Taiwan Experience*, ICEE'2003, 21~25 July. 2003

LEE, M.Y., *Mechatronics in Medical Modality Development*, IEEE International Conference on Robotics and Automation, Vol. 3, 2002, pp. 2950 –2955

LEE, M,Y. LIN, Y,S. *Design of a Transformable Driver Seat / Wheelchair Automatic Lifting System*, Proceeding of 2003 Chinese Biomedical Engineering Conference, December 2003.

LEE, M,Y. LIN, Y.S. *Transformable Driver Seat / Wheelchair Automatic Lifting System*, Patent Pending July 2003.

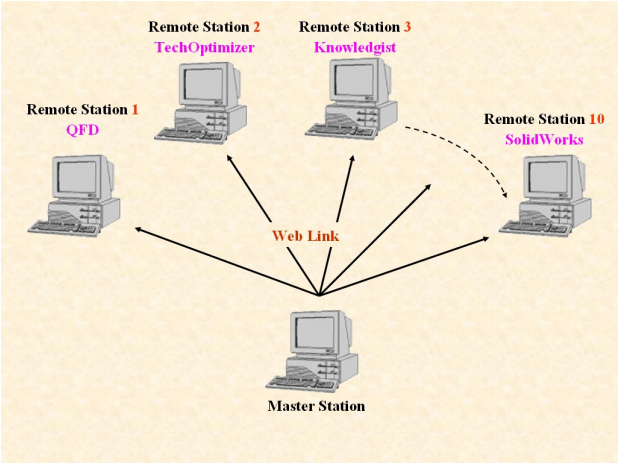

Figure. 1 System Architecture of Virtue Product Development Experiments (VPDE)

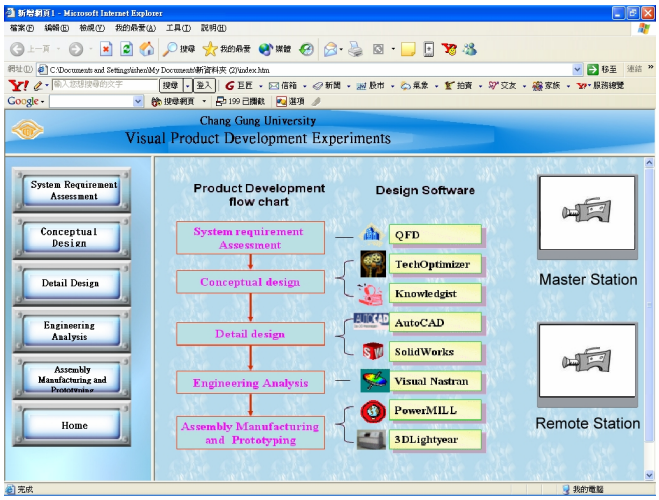

Figure. 2a Main Control Screen for VPDE.

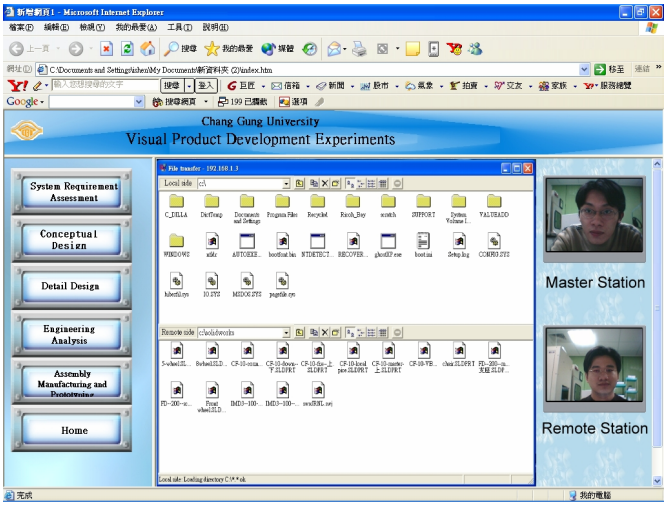

Figure. 2b Upload and download control Screen between local and remote stations

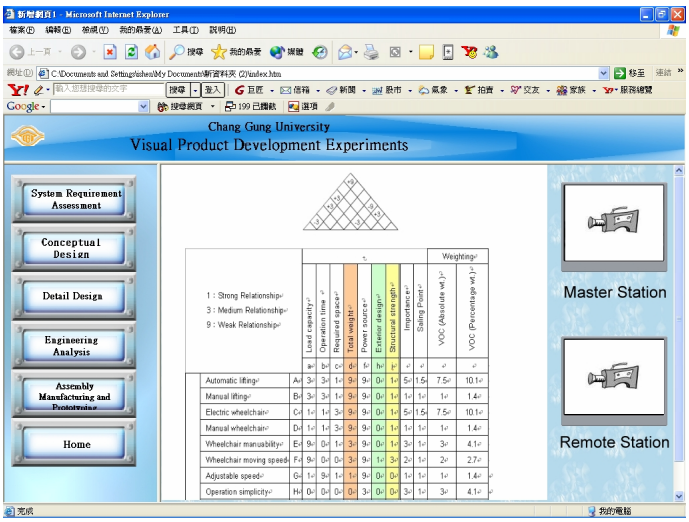

Figure. 3 House of Quality (QFD)

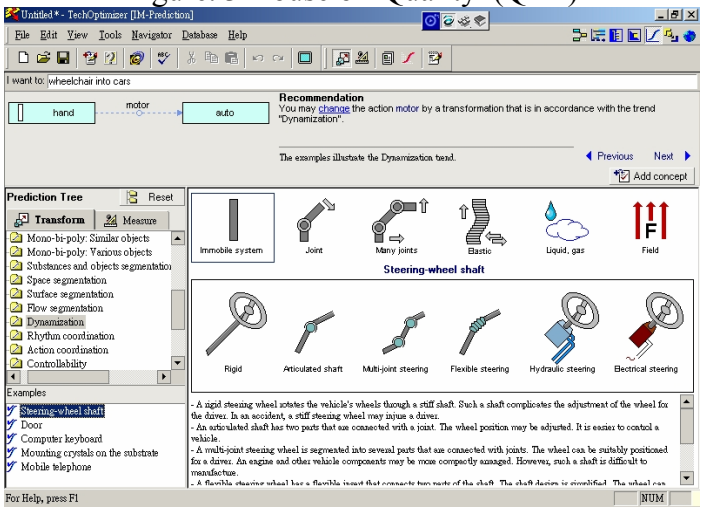

Figure. 4A Conceptual Desig n Illustrations (Techoptimizer)

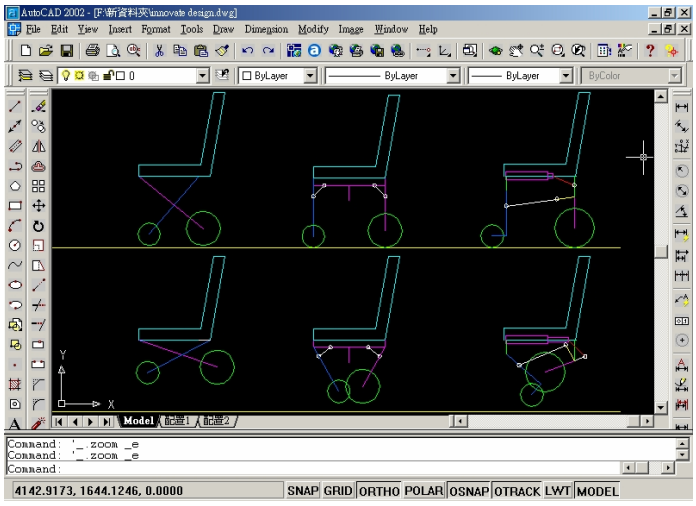

Figure. 4B three conceptual designs for wheelchair folding mechanism (techoptimizer)

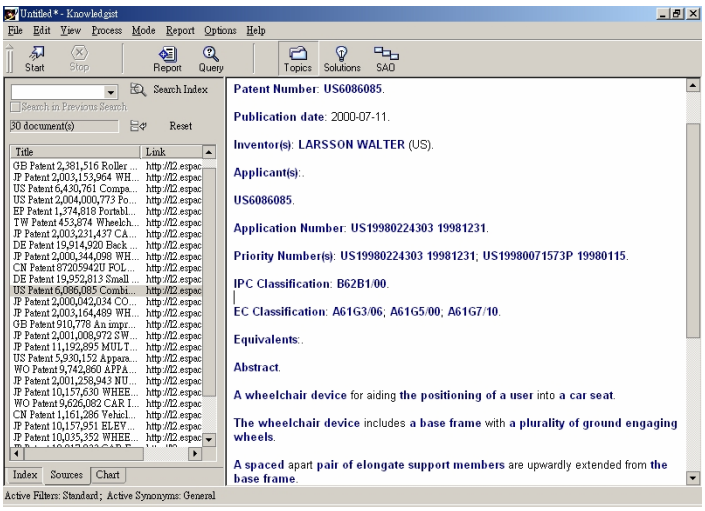

Figure. 5 patent search ans analysis (knowledgist)

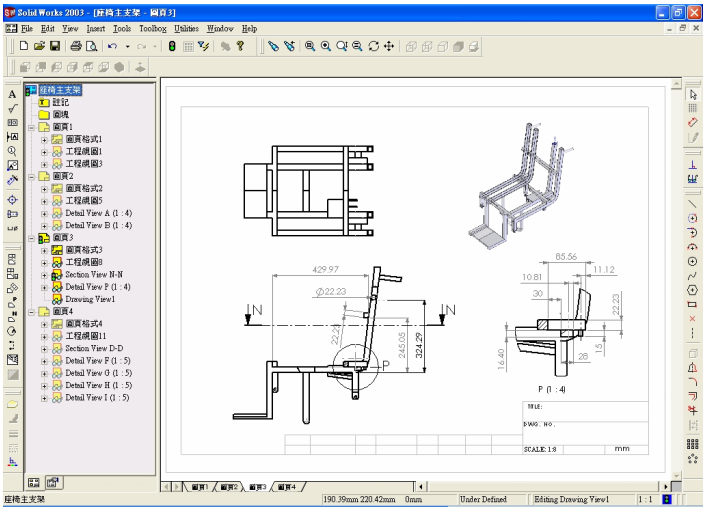

Figure. 6A isometric and detailed design drawings (solidworks)

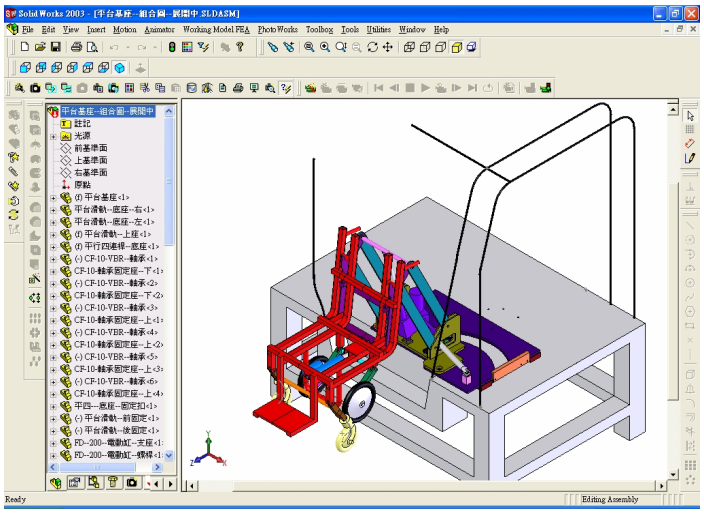

Figure. 6B kinematic simulation for wheelchair lifting motion (solidworks).

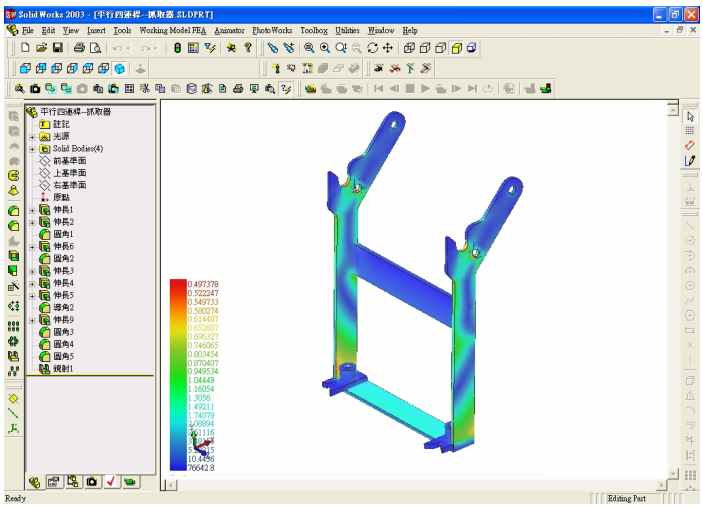

Figure. 7 finite element structural analysis (solidworks)

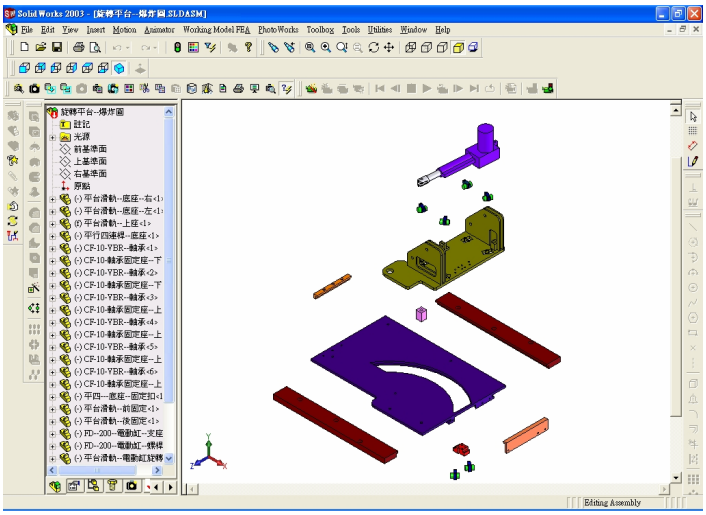

Figure. 8 assembly analysis (solidworks)

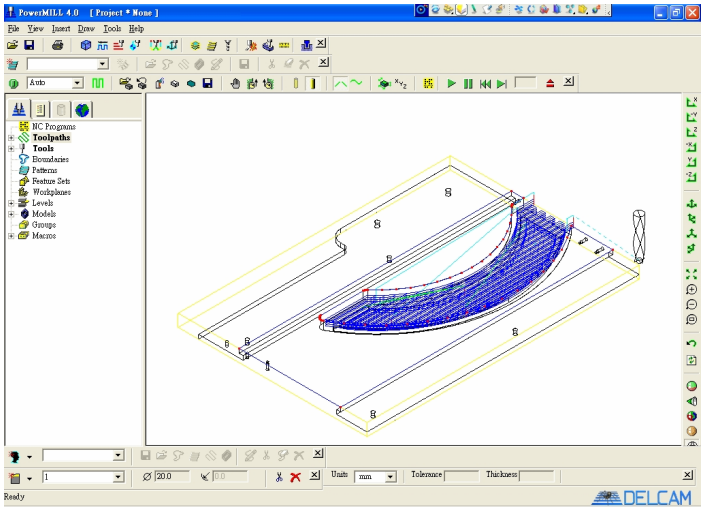

Figure. 9 cutting toolpath simulation (powermill).

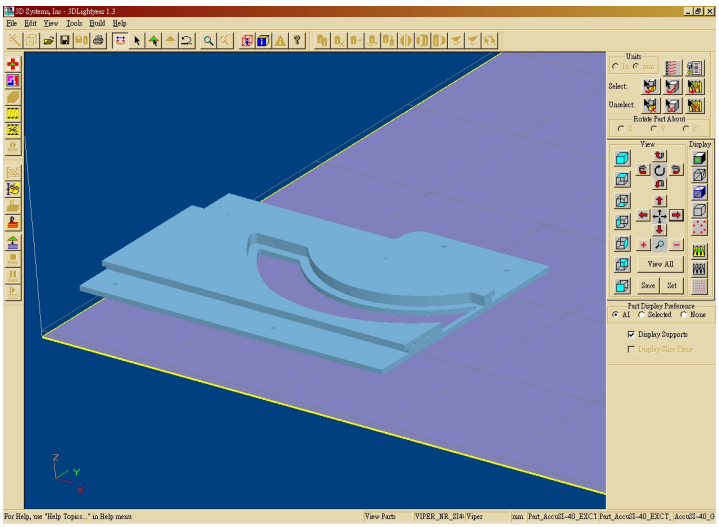

Figure.10a virtue operational panel for rapid prototyping machine

Figure.10B picture of rapid prototyping machine (3d system, usa)

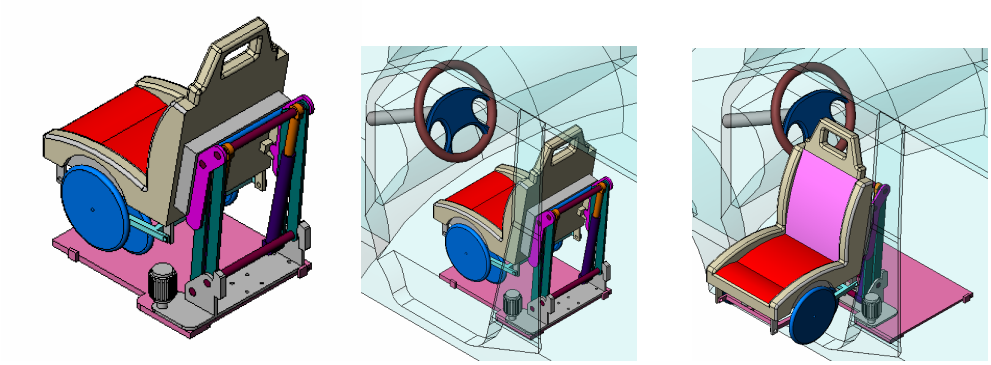

Figure.11 Final product of student hands-on-design project