AC 2007-2699: HANDS-ON SOLID MODELING EXPERIENCES IN A COURSE PROJECT

Jahangir Ansari, Virginia State University

JAHANGIR ANSARI is an Assistant Professor of Manufacturing Engineering in the Department of Engineering and Technology at Virginia State University. He received his M.S. degree in Mechanical Engineering in 1979 and Ph. D. degree in Mechanical Design and Production Engineering in 1983 both from Seoul National University. He joined the faculty at VSU in 2002. He has over 18 years of industrial experience in different areas including shipbuilding and cement plant industries. His research interests include Structural Vibration, FEM, CAD/CAM/CNC, and Computer Integrated Manufacturing.

Hands on Solid Modeling Experiences in a Course Project

Abstract:

This paper focuses on the hands-on experience of 3-D solid modeling technique and prototyping employed in product design and realization process. Engineering Graphics and CAD/CAM are two of the core courses in the Manufacturing Engineering program. Computer aided design and drafting, as well as solid modeling of parts, are strongly emphasized in the Engineering Graphics curriculum which is taught in the sophomore year. In continuation, both manual and computer aided CNC programming are covered in the CAD/CAM curriculum taught in the junior year. Computer Aided Reverse Engineering of cork opener, gear puller, cell phone case, and cell phone cover were the selected course projects taken by students in the CAD/CAM course. One of the main objectives of the curse project was for the students to extend their knowledge in design process and gain a hands-on experience in the field of solid modeling and product realization. A caliper and a micrometer were used to measure the main dimensions of the parts, and a solid modeling program was used for creating the parts model and assembly as well. This paper describes hands-on solid modeling and prototyping experiences of manufacturing engineering students regarding product realization process at our program.

Introduction:

A survey conducted by Egggert [1], indicates that universities and industries suggest that an engineer should be skilled and capable to design a part and assemble a product using CAD/Solid Modeling upon graduating. Solid modeling is a vital step in a product design and manufacturing. A review of literature indicates the need of industries for engineers with advanced knowledge and skills in engineering design, Design For Manufacture (DFM), Design For Assembly (DFA), manufacturing process, and materials [1, 2]. Among the several competencies desired by job market, engineers having ability and skills to design a part and assembly of a product using solid modeling software are highly in demand.

Therefore, like most engineering programs [3 - 6], our manufacturing engineering program at Virginia State University places a great emphasis on hands-on activities in its curriculum in part design and product assembly competencies.

Engineering Graphics (ENGR 200) is a two credit hour course which is taught in the sophomore year. In this course students get familiar with 2-D drafting and 3D solid modeling and assembly of simple products. CAD/CAM (MANE 310) is a three credit hour course which is taught in junior year. In this course computer aided solid modeling and assembly are practiced in terms of a course project for design and product realization purpose. Students are asked to search for a product consisting of two or more components and to use our facilities to design and build a prototype model. Students then come up with different ideas to present and discuss in class and select the most feasible one as a course design project. In the second part of the course, which deals with CNC programming and operation, students are asked to produce a simple product utilizing CNC machines. Using 3-D Solid Modeling and CAD/CAM software to design the model and generate the tool path for machining help students to simulate the final product and debug any error or misplacements that may have occurred during the design phase of the product. Only solid modeling and prototyping projects are discussed in this paper.

Course Projects:

Recently several products were designed and produced in the CAD/CAM course project. Some selected works are presented in this paper. The CAD/CAM class was asked to search the internet along with any other sources to find ideas for the course design project. The ideas needed to be of a product presenting functionality, engineering, and challenge to the students' skill level for design. The product should possess two or more parts and should be completed within the given time period. The projects are graded according to creativity, level of challenge, accuracy, quality of final product, and peer presentation evaluation.

Choosing a project topic:

In the beginning of the project; students were asked to search and find at least five ideas in which they are interested to work on as the product realization course project. The selected idea should encompass the qualities needed as well as fit to the levels of their confidence. The purpose of this activity was to help students "warm up" by generating a number of ideas before choosing a project.
The sequence in a product development starts with the geometric modeling utilizing 3-D solid modeling software. In this process, students use their knowledge and skills of solid modeling and assembly gained in the ENGR 200 course, and design and prototyping learned at the beginning of the MANE 310 course to design and visualize their selected ideas. Since the selected projects consist of two or more parts, functionality issues become challenging for students. Students realized that, although creating a single complicated part may not cause serious difficulties for them, in assembly process, a verity of design and analysis challenges are presented. A few selected projects done by the students in CAD/CAM course are discussed bellow.

Gear puller:

This is a mechanical device used to remove gears, bearings, and pulleys from a shaft.
Upon evaluation of several ideas as well as some input from the class students, one of the students chose a gear puller for his project. The idea of using a gear puller came from the actual use of the device in his profession. This was a good selection, because the concept of gear pulling itself is a blend of several engineering practices. The design would be challenging, but it would be in the realm of the student's personal knowledge and abilities with the geometric analysis and solid modeling skills. The design of this device needs to be accurate and precise enough to handle the work that it required of it. The amount of force needed to remove a gear from a shaft can sometimes exceed the capabilities of the tool itself, resulting in the tool failure. Keeping consistent with the geometric configuration and functionality, the student can make adjustment on the overall shape and use of the final product.
The gear puller is an assembly of four parts and would need to be capable of disassembling to reverse the arms to increase the functionality of the device. The four parts of the gear puller are: the body (1), the arm (3), the adjustment shaft, and the pin (3). The student expressed the followings in his final presentation:

> *"In conclusion, this project was a solid working of the ideas and tools that Manufacturing Engineer will need to posses in order to be successful. It is a*

good practice of how to start a project and follow through with an idea, from measurement to paper and finally design. The difficulties I experienced in the mating of the body and shaft shows an area of weakness with my use of the software and provides me with a direction of learning. The project overall turned good, other than the threads."

The assembly model and the prototype model of the designed gear puller are shown in Figure 1.

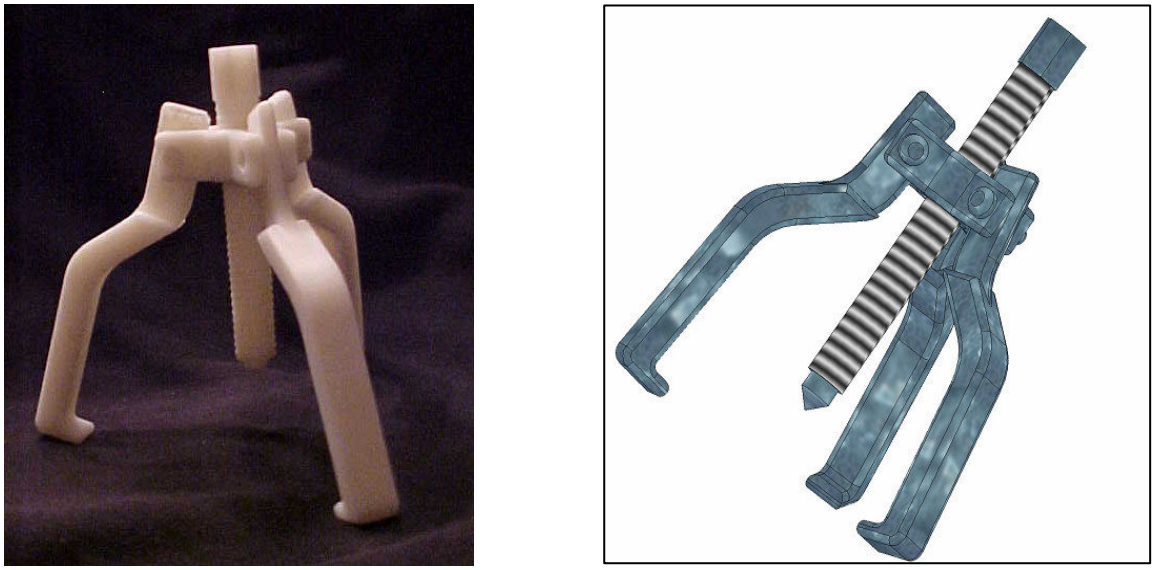

Figure 1. The prototype and assembly model of the Gear Puller.

Corkscrew:

A corkscrew is a device for removing stopping corks from wine bottles. This device comprises a pointed metallic helix attached to a handle. The handle allows for a fine and commanding grip making removal of the stopper relatively easy. Many corkscrew handles incorporate levels that further increase the amount of force that can be applied outwards upon the cork.
The student put the reason of selecting this product for his project in his oral presentation as:

"I finally came up with a new idea and decided to make a double-winged lever corkscrew. I chose the corkscrew because I wanted to do something different and challenging. I thought the corkscrew wouldn't be too hard to design and it would be interesting to make something that has moving parts."

The challenging part of this project was the dimensional configuration of the parts to insure the workability of the mechanism of the product. To design the parts insuring the relative motion between the screw handle and the levels after assembly requires detailed geometrical calculations. This was a challenge for the student involved in this project.
The corkscrew has 4 basic parts named: the screw handle (1), the body (1), the lever (2), and the pin (2). The exploded and assembly models of the designed corkscrew are shown in Figure 2.

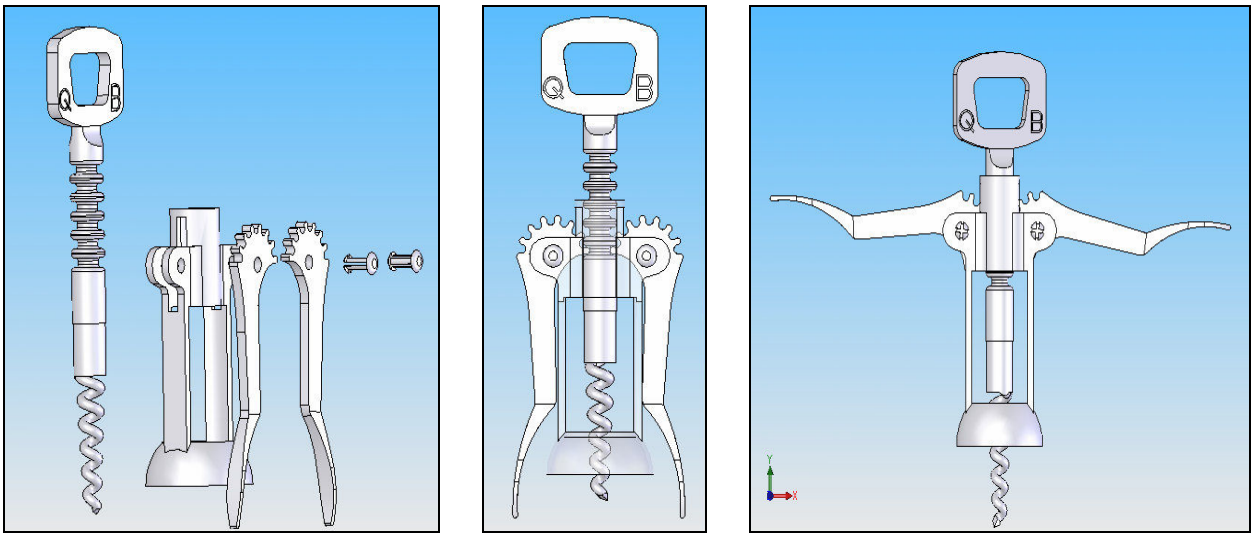

Figure 2. The exploded, assembly, and prototype models of the Corkscrew.

The photographs of the actual corkscrew and the prototype product are shown in Figure 3.

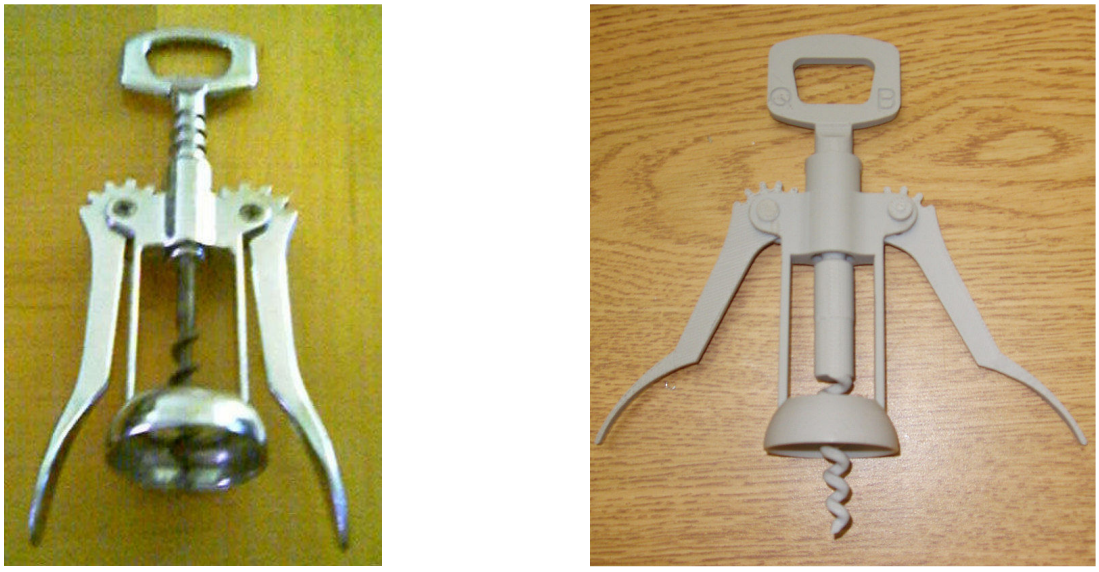

Figure 3. The actual and prototype of the corkscrew.

Cell Phone Cover:

The design and build a cell phone cover (shell) was selected by another student. The challenging part of this project was to identify and design the fitting conditions of the two parts. She expressed the following in her final presentation.

> *"I didn't have the actual cell phone cover; therefore I used the few dimensions that were given in a picture of a cell phone I found during my search for a project topic". In Conclusion; "In the Computer Aided Design (CAD) and computer Aided Manufacturing (CAM) I learned how to design in 3D dimensions and produce a final product using a prototype machine."*

The 3-D solid model of the assembled product and prototypes of parts are shown in Figure 4.

Figure 4. The assembly and prototype models of the Cell.

Cell Phone Case:

A cell phone case was the topic selected by another student. The idea came up from a real cell phone case which was available to redesign from. The product consists of two parts which are connected to each other by a hinge that fastens the cap to the body. The challenging part of this product was the co-linearity of the hinge axis, which occurs in the assembly process.
The assembly model and the prototype models of the product are shown in Figure 5.

Figure 5. The assembly and prototype models of the Cell Phone Case.

Other Projects:

There were several other projects with different levels of difficulty. Some of the products are shown in the Figure 6.

Figure 6. The Solid Models and prototype models of Students' Projects.

Assessments:

Several methods were employed to assess the students' learning outcomes. Peer evaluation of the projects was conducted in class presentations. Course project evaluation was conducted by faculty in Students' Projects Presentation Day on the last week of each semester. A survey was conducted in the classes of MANE 310 and ENGR 200 to collect the learning outcomes and the interest areas of the students enrolled in these courses. The results of the survey collected from seventeen students involved in product realization projects are shown in Figure 7.

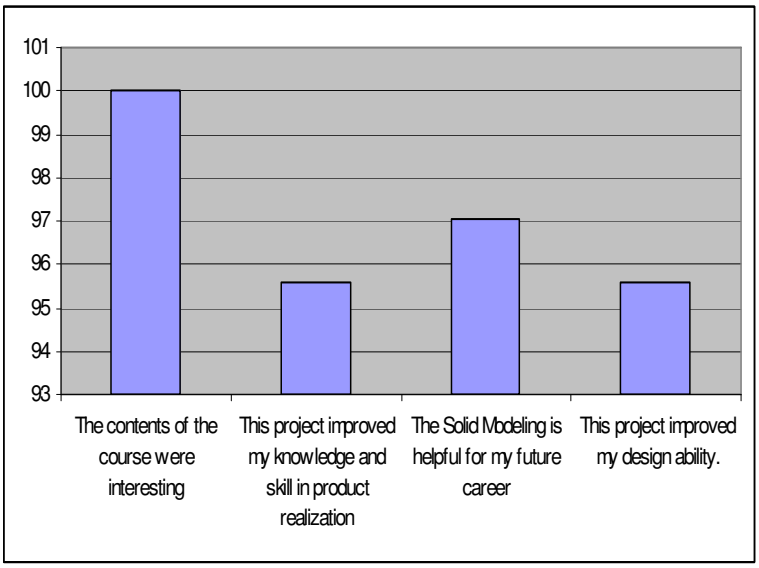

Figure 7. Result of the students survey

Conclusion:

In conclusion, project based teaching of design and product realization gives students the chance to develop their creativity, critical thinking, and hands-on skills in the areas of their interest. In the peer evaluation process during the project presentation they learn from each other and learn to critique constructively. In the project time frame several short structured events are arranged, in which the students discuss the work they have done so far, the difficulties they have, and their plans in completing their projects. In these short events students can learn a lot from each other. The following are some opinions of the last class participants.

- *To find thoughts and ideas was not easy.*
- *The design of my product was challenging.*
- *The concept seems easy but the amount of engineering that takes place in the design process of a product is vast.*
- *The assembly was by far the most difficult part of my project.*
- *Creating and matching the threads proofed to be an area of limited ability.*

In this activity the students establish an understanding of what's important in a topic choice, brainstorm and discuss topic ideas, and explore several suggestions for making the project relevant to real world situations.

Bibliography

1. Rudolph Eggert, DESIGN FOR MANUFACTURE AND ASSEMBLY: A SURVEY OF DESIRED COMPETENCIES, Proceedings of the 2006 ASEE Annual Conference, Chicago, Illinois
2. Joseph C. Chen and Jacob Chen, Integrating Design and Manufacturing Concepts to Strengthen Advanced Technological Education Programs, Proceedings of the 2004 ASEE Annual Conference, Salt Lake City, Utah.
3. Ronald E. barr , Philip S. Schmidt, Thomas J. Krueger, and Chu-Yun Twu, An Introduction to Engineering Through an Integrated Reverse Engineering and Design Graphics Project*, Journal of Engineering Education*, October 2000.
4. Jorge Rodriguez, Alamgir Choudhury, Mitchel Keil, Sam Ramrattan, and Pavel Ikonomov, Application of Rapid Prototyping For Engineering Design Projects, Proceedings of the 2006 ASEE Annual Conference, Chicago, Illinois.
5. W. Lawrence Neeley, Sheri Sheppard, and Larry Leifer, Design is Design is Design (OR IS IT?): What We Say vs. What We Do in Engineering Design Education, Proceedings of the 2006 ASEE Annual Conference, Chicago, Illinois.
6. William Howard and Joseph Musto, Solid Modeling as the Cornerstone of an Introduction to Engineering Course, Proceedings of the 2006 ASEE Annual Conference, Chicago, Illinois.