A Hands-on Project approach to Teaching Solid Modeling

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Abstract

This paper describes an integrated laboratory-oriented course MET/MFG407 in computer-aided Design at Oregon Institute of Technology. Teaching this subject in an 11-week of academic quarter is a challenging task requiring a combination of instructional delivery methods. Besides the in class lectures on the different aspects of using the CAD software; each student is also given a toy robot kit to be modeled. The course content is designed around three learning objectives: be able to create parametric models, be able to generate the associated 2D multiview drawings of the solid models, be able to create assemblies and animations of the solid models, and perform kinematic analysis of the given design. The author will share his observations and experience with educators in the field.

Computer-aided-engineering tools, such as CAD, FEA and CAM, are becoming to be the essential tools to the engineering practices in industry. This paper describes the development of an applied Solid Modeling course that is being offered by the Mechanical and Manufacturing Engineering Technology (MMET) department at Oregon Institute of Technology.

Solid Modeling is an important part of Computer Aided Design (CAD) technology, which can be used to aid the creation of better Designs. At Oregon Institute of Technology, the first Solid Modeling course was first developed and taught back in 1987; and with the developments of the other leading edge technologies, we now see very exciting changes in how an engineer perform his/her daily tasks in industry. In 1996, the MMET department began to incorporate the parametric modeling software in the MET and MFG programs.

In the Spring term of 2011, an elective course (MET/MFG 407 Advanced Solid Modeling) was developed and offered. Students are required to have finished the required MET 375 Solid Modeling class to enroll in this course. A different Parametric Modeling software is used in this second solid modeling course. The course has been offered every year since 2011.

The main emphases of the course are placed on both teaching the students to use a commercially available parametric package and have the students performing the modeling and analysis tasks of a toy robot kit. The course objectives have been established as follows:

- To learn the basic concepts and procedures associated with using a commercially available Parametric Modeling package.
- To understand and use the tools available in 3D Parametric Modeling technology.
- To generate 2D working drawings of the 3D models.
- To learn and perform 2D and 3D kinematic analysis using modern computer software.
- Apply the techniques and skills taught to related problems in follow-on courses.

This paper describes the changes and results of the Advanced Solid Modeling course offered by the Mechanical and Manufacturing Engineering Technology Department at Oregon Institute of Technology.
Development of the Advanced Solid Modeling course at OIT

Parametric Modeling technology has become the main 3D modeling technology in Computer Aided Design (CAD). The Parametric Modeling Technology was first introduced in 1989, which has revolutionized the CAD industry as it can be used to aid the creation of better designs. In 1994, with the help of several education grants from industries, including the Boeing Airplane Company, Schroff Development Co. and Autodesk Co. The OIT-MET department did a two year research on incorporating the leading edge Computer Aided Engineering technology into the MET and MFG programs at OIT. As a result of that research, a series of computer aided engineering (CAD/CAM) courses were developed and incorporated into the two engineering technology programs. In 1996, the MET department at OIT offered their first Parametric Modeling course; the course was a required course for both the MET and MFG programs. The course replaced the previously required Solid Modeling course; the new course emphasizes more on the design aspects of Mechanical Designs and also the hands-on experience in using a commercially available Parametric Modeling package.

In 1998, the MMET department at OIT purchased a Rapid Prototyping (RP) machine and a 3D scanner. The combination of these technologies has enabled most of our students to be more creative and productive in doing design works. The faculty of the MMET department at OIT felt it is also necessary to expose students to the different flavors of available Parametric Modeling packages. Through the help of several education grants from industries, the following parametric modeling packages are now available in the OIT CAD/CAE Labs: Creo Parametric, Autodesk Inventor, SolidWorks and Unigraphics NX series. In the Spring term of 2011, an elective course, MET 407 Advanced Solid Modeling, using a hands-on project approach, was developed and offered. The course has been offered every year since 2011.

The main emphases of the course are placed on both teaching the students to use a commercially available parametric modeling software and to have the students go through the basic mechanism analysis and design process. The students are also given a specific design task, currently the design task is to improve the walking motion of the given robot kit.

Course Description

The current format of the course contains three components: (1) The use of a commercial Parametric Modeling package. Currently the SolidWork and Autodesk Inventor software are used. (2) The practical training of measuring and modeling actual parts. (3) The analyzing and re-designing of an actual product to further reinforces the concepts and principles learned in related engineering design courses. By integrating the project into the 2nd half of the course, the insights and strengths of using the Parametric Modeling software can be better observed.

The course is structured in a 2-3-3 format (2 hours lecture, 3 hours lab, 3 credit hours) and the class meets for 5 hours per week. A typical week consisted of about 2 hours of classroom time and 3 hours in the computer labs. The class also has access to a classroom and a computer lab. Activities of the ten weeks term includes the discussions of the basic parametric design techniques, paralleled by using a commercial parametric modeling software to aid the design task.
The course objectives have been established as follows:

- To learn the basic concepts and procedures associated with using a commercially available Parametric Modeling package.
- To understand and use the tools available in 3D Parametric Modeling technology.
- To generate 2D working drawings of the 3D models.
- To learn and perform 2D and 3D kinematic analysis using modern computer software.
- Apply the techniques and skills taught to related problems in follow-on courses.

The course begins by covering the three basic components of a parametric modeling software: (1) Part Modeling, (2) Creating 2-D multiview drawings from 3-D models, and (3) Assembly Modeling. In the second half of the course, each student is given a different toy robot kit to be modeled in the parametric modeling software. The chosen toy robot kits each contain about 30 parts to be modeled. The use of the standard part library and using the gear generator, available in the parametric modeling software, are also covered. The students are required to first measure and model each part in the kit and also create the associated assembly model.
One Main Component of Parametric Modeling covered in the course

1. Part Modeling
2. Creating 2-D Drawings from Solids

3. Assembly Modeling and Animations
Kinematic Analysis and Simulations

After the students have modeled the toy robot kit, the students are also required to perform kinematic analysis and simulations using the Parametric Modeling software and the GeoGebra software. The GeoGebra software is a dynamic geometry program simulating compass and straight-edge constructions on a computer. The software is designed and maintained by Professor Markus Hohenwarter of University of Salzburg in 2001. The GeoGebra software runs on JAVA technology as a local appication or as an applet in a browser. The free program includes documentation and tutorials. The software has received over a dozen of Educational Software awards. The program currently support several platforms and also available in many languages.

Although the GeoGebra software is a 2-D geometry software; it provides two main features suitable for kinematics analysis purpose: Motion simulation and Loci tracking.
Conclusions

In the past 30 years, the advancements in CAD (computer aided design) technologies are truly amazing. The Engineering and Engineering Technology Students today are very fortunate to have all these very powerful tools to aid their career as an engineer; but at the same time, the students also have to devote themselves and be quite proficient in using these tools.

In this course, students are exposed to many elements of machine designs through the use of tools available in CAD and Solid Modeling. The elements associated to the course provide activities that are very challenging, but the results are also very rewarding. The most significant feedback from the students enrolled in the 2014 class has been that although this hands-on approach requires more time and work, but the use of actual parts have provided the students a different perspective of using the parametric modeling software.

As an assessment of learning, the students enrolled in the Advanced Solid Modeling course are also required to take the Certified SoldWorks Association (CSWA) Examination. The score of the CSWA Examination is also counted as thirty percent of the final grade of the course. The average passing rate for the OIT-MMET students who took the Advanced Solid Modeling course is around ninety percent, which indicates this new approach does help the students in building their skills of using parametric modeling. Note the world wide average passing rate of the CSWA Examination is around fifty percent.

Through the experience of the course, a manuscript was developed in 2012. The manuscript was first tested, through the help of Mr. Don Domes, at Hillsboro High School in Hillsboro, Oregon. Several of Mr. Domes’ robotic teams tested the manuscript; the teams were formed mostly by students without any solid modeling background. The initial feedback from Mr. Domes’ students indicated the learning of parametric modeling by modeling actual parts seems to trigger more interest as well as more excitements among students. The manuscript was then modified and published in 2012 and currently having over fifty schools in noth-America using the text in beginning engineering courses.

This paper has presented the undergraduate course of an advanced solid modeling course offered by the MMET department at Oregon Institute of Technology. The course provides students with very practical hands-on experience of the modern technology tools available for product analysis and design. The success of the course showed that the hands-on approach can be just effective, if not more effective, in enhancing the teaching and learning of parametric modeling technology.