Improved Visualization through Association - Connecting Engineering Graphics to Animations and Engineering Simulations

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Abstract

The traditional engineering graphics course, developed for mechanical engineering freshmen, teaches the ability to create and interpret standard 2D drawings, incorporate functional design and manufacturing requirements of 3D parts, along with basic engineering principles and design intent, using CAD software.

Through registration data, non-freshman and other majors take this course. Incorporating non-conventional visualization techniques: animation, engineering simulation, rapid prototyping, photorealistic rendering, and augmented reality, assist students in their upper level classes.

From Drawing Strengths to Engineering Principles

Engineering students enroll in a basic course in engineering graphical communications, required by mechanical engineering students and optional by other disciplines. Student competencies include the ability to create and interpret standard 2D drawings, incorporate functional design and manufacturing requirements of 3D parts, along with basic engineering principles and design intent, using CAD software according to ASME Y14 standards.
Students develop drawing strengths and make connections to future engineering principles and practices. The advances in technology make the use of visualization, animation, engineering simulation, rapid prototyping, photorealistic rendering, and augmented reality relevant early in the student's education.

Four years ago, the introductory course ran in a serial progression using model demonstrations in software with little or no animation, simulation, photorealistic rendering, or augmented reality. Students learned view orientation, orthographic projection, 2D drawings, planes, sketching techniques, and basic model feature construction.

Students created fixed assemblies. They learned the ASME Y14 drawing standard and applied it to create part drawings and assembly drawings from a selection of classic models such as a Geneva gear mechanism or mechanical vise.

So how do you keep the drawing competencies and increase visualization skills required for different backgrounds, ages, and future courses with no additional time? Answer: change the course organization, create a library of models based on student majors, and vary the use of lecture/lab time. In the first three lectures, students are introduced to reading and interpreting drawings, illustrating model behavior with animation, and associating models with engineering applications through engineering simulation, all in parallel with the geometric model.

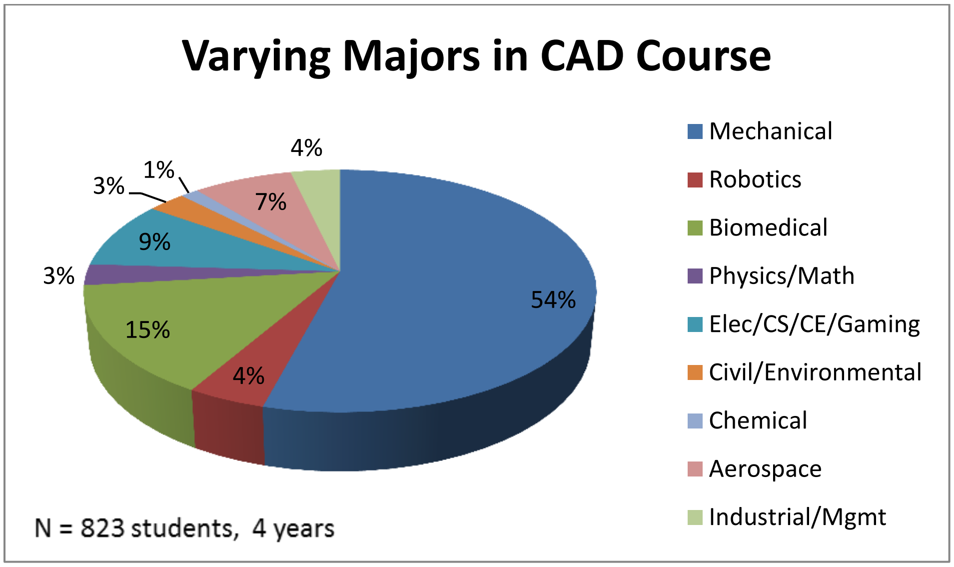

Figure 1. Varying Majors, 2009-2010, 2010-2011, 2011-2012, 2012-2013

Through registration data, 54% of the students were studying mechanical engineering as illustrated in Figure 1.

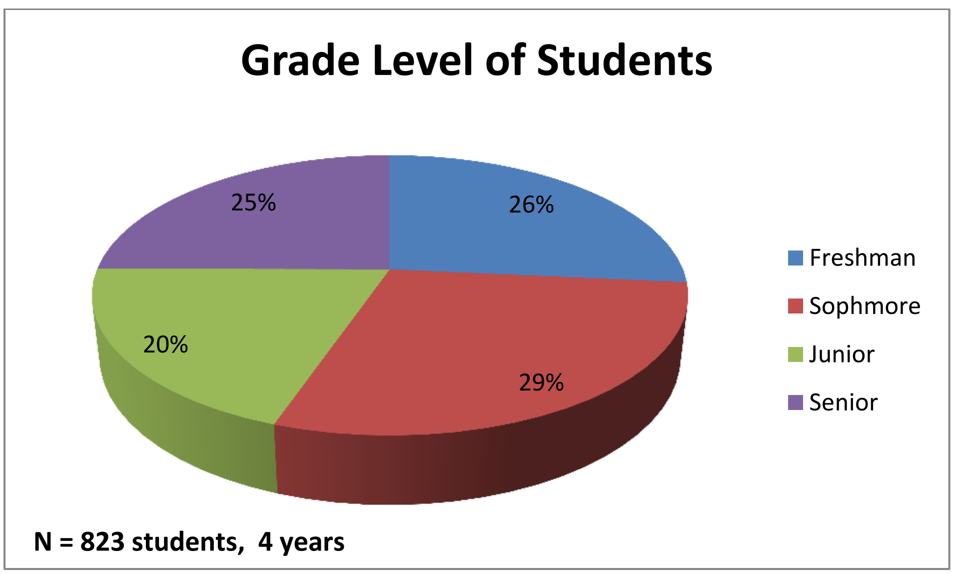

Figure 2. Varying Grade Levels, 2009-2010, 2010-2011, 2011-2012, 2012-2013

Approximately 26% of 31 sections, since 2009 were actually freshman as illustrated in Figure 2. The amount of freshman per section varied during different times of the year. Every model begins with an animation to illustrate its working physical behavior. Presented, through engineering simulation and animation are short introductions to future engineering principles that students will learn in upper level courses such as kinematics, fluid dynamics, stress analysis and sustainable design. Illustrated models include pumps, valves, 4-bar linkages, Geneva gear mechanisms, mechanical vise, binder clips, and plastic bottles.

Models are provided for Mechanical, Aerospace, Biomedical, Civil, Electrical, Gaming, Robotics and Physics/Math students, now based on previous students' final projects. By illustrating previous students' work, with no previous CAD experience, new students see what they can accomplish. The stage is set for new students to learn more and to do more. With simulation, first year students, without theoretical prerequisites, understand simple boundary conditions, applied forces and the resulting animations.

Once students understand how the assembly works, the model is broken down into its components. Now students must answer the questions on how to create the parts. With design intent of the sketch, the features and the part, students learn to design for future changes and to produce different results. At the same time, students are learning drawing skills. Students read dimensions and tolerance, fastener annotations, manufacturing notes, and fit types on existing drawings to create parts. For the final project, they create engineering drawings based on their parts and assemblies per the ASME Y14 drawing standard.

For Extra Credit

Students learn how to create and animate an exploded assembly view with a Bill of Materials, Balloons, Notes, and a Revision table. For extra credit, they are quickly shown photorealistic rendering, animation, and simulation of a model. In 2012, 91% of 156 students received extra credit applying photorealistic rendering and creating an animation and or engineering simulation – even though concepts were never officially taught or required as outcomes.

With the introduction of non-conventional visualization techniques; animation, engineering simulation, rapid prototyping, photorealistic rendering, and augmented reality, to engineering graphics, course enrollment has increased over the past 4 years and is now consistently taken as an elective by students in engineering (aerospace, biomedical, chemical, civil, electrical, gaming, industrial, robotics), and science and mathematics. Enrollment limits now are based on classroom space and instructor availability.

Library

With a diverse student population, lecture/lab time features non-conventional visualization techniques relevant to student background and level. An engineering library is available where instructors can display animations from a variety of models, created by past students with no former experience.

In addition to course requirements, students select a final project to successfully complete the course. During the first week, they are presented with a series of final project options as listed below.

Option 1 Minimum requirements: Select a standard final project. Create all parts and the final assembly. Create all part and assembly drawings with required views and a BOM and Revision table.

Option 2 Additional credit: Select a standard final project and modify it. Create all parts and the final assembly. Create all part and assembly drawings with required views and a BOM and Revision table. Create a basic animation and simulation of the assembly. Apply photorealistic rendering to the final assembly.

Option 3 Additional credit: Create a final project, with instructor approval. Final projects are related to student major or interest. Create all parts and the final assembly. Create all part and assembly drawings with required views and a BOM and Revision table. Create a basic animation and simulation of the assembly. Apply photorealistic rendering to the final assembly.

Based on six sections in 2012-2013, 156 students, 38 freshman, 85 mechanical engineering majors, 15% of students chose Option 1, 10% chose Option 2 and 75% chose Option 3 for their final project.

Expanding Visualization Skills

Students explore geometric models using new technology such as affordable rapid prototyping and augmented reality with smart devices. For example, all students, for a fee, can produce a rapid prototype of their models. Since students have to pay, there is a sense of getting the dimensions, tolerance and fit right the first time from the corresponding engineering drawing.

Augmented reality software provides the student a visual perception of the geometric model in the environment that is mediated. In a product concept sketch, the designer places a pencil, penny, or coffee cup to convey the sense of scale. When students create a 3D model, their perception of scale is skewed just looking at the model in the graphics window.

Utilizing augmented reality, students visualize the 3D model with a sense of scale. A Quick Response Code (QR) activates a smart device with a camera. A true model, 1:1 scale, can be displayed. Students understand the actual size of the CAD model and manipulate the model through either an iPhone or iPad. Scaling the QR code allows larger objects to be displayed.

Summary

Animation, engineering simulation, rapid prototyping, photorealistic rendering, and augmented reality, show students the capabilities and potential for utilizing these tools during their academic courses and professional careers.

References:

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