A Comparison of Solid Modeling Curriculum Approaches

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Abstract

Many schools have recently introduced solid modeling to their curricula in Engineering Design Graphics. Some courses introduce solid modeling at the end of a traditional 2D CAD course, whereas others begin with the solid model. Some, but not all, of the concepts traditionally taught in conventional drafting or CAD courses are necessary to the development of solid models, and additional concepts are needed which are unique to solid modeling but unnecessary in conventional CAD. It is hypothesized or assumed by many that the use of solid modeling will enhance students' visualization skills. If this is so, then which topics should be presented to the students first in order to enhance their learning and improve visualization skills? This has been the subject of much debate within the EDG community. This study looks at the development of a solid modeling based CAD course and compares the outcomes derived from varying the order of presentation of the content.

Introduction

Engineering design graphics educators began to introduce solid modeling to the curriculum in the early 1990s (eg. Barr & Juricic[1]). Over the past decade, manual drafting has been virtually eliminated from the curriculum in most 2- and 4-year engineering colleges (eg. Nee[2]), and even 2D CAD is becoming less prevalent than 3D solid modeling in the introductory graphics courses (Baxter[3], Branoff *et al.*[4], Meyers [5]). During this time, there has been much discussion concerning the topics that should be taught and the core competencies that should be developed by students in EDG courses (Crittendon[6], Ault[7], Branoff *et al.*[8]). In general, graphics educators agree that the development of spatial visualization skills is an important objective of the EDG curriculum, regardless of the content or approach to CAD or geometric modeling used. However, there has been little research into the question of how best to introduce 3D solid modeling in order to have an impact on the development of these skills.

One method of assessing student development is through the use of standardized tests. In the area of engineering graphics and visualization, the Purdue Spatial Visualization Test: Rotations[8] has been widely used. This test asks students to visualize the orientation of object rotations. More recently, Young & Sorby[9] have developed a more comprehensive test with fifty (50) questions covering nine different visualization skills.

The objective of this study is to determine whether different approaches to teaching solid modeling will have a significant effect on the development of graphics skills in an introductory computer-aided design course.

Methodology

Solid modeling was introduced to the introductory computer-aided design course in the fall of 2002. The course is designed for first-year students with no graphics or CAD background. The principal objectives of the course are to create feature-based parametric solid models of parts and assemblies using proper modeling strategies to capture design intent and to create and interpret ANSI standard detail and assembly drawings based on the solid models. Two sections of the course were taught using different sequences of topics. Approximately sixty (60) students were enrolled in each section. Although the same material was covered by both instructors, one section focused on solid modeling strategies during the first part of the course, followed by more traditional topics of visualization skills, orthographic drawings and dimensioning, then assembly modeling and assembly drawings (S-D). The second section covered visualization skills, multi-view drawings and dimensioning at the beginning of the course, followed by solid modeling methods, then assemblies (D-S). Both sections used the same texts[10,11] and completed the same laboratory assignments.

Students were asked to take the Sorby test[9] at the beginning and end of the course. The test was administered on-line in sections of ten questions, to facilitate web access. Students that took the on-line tests were awarded one perfect quiz grade as an incentive to complete the test. The on-line test scores did not otherwise impact the students' grades. In addition to the fifty questions on the Sorby test, students recorded the time taken to complete the tests.

Results

Table 1 shows the results of the test scores for both sections of the course.

Table 1. Results of Sorby Visualization Test for Introductory CAD students

Section		Pre-test Score	Post-test Score	Score Change	Pre-test Time (min.)	Post-test Time (min.)	Change in Time (min.)
Section S-D	Avg	22.6	27.3	4.79	46.9	32.8	-14.1
Solids →	SD	7.03	8.16	7.51	19.7	13.4	-6.33
Drawings	Min	9	11	-21	23	12	-11
n=29	Max	37	43	16	101	59	-42
Section D-S	Avg	23.1	26.8	3.64	58.5	41.9	-16.6
Drawings →	SD	7.28	9.76	7.86	23.0	13.4	24.8
Solids	Min	14	12	-9	27	22	-78
n=14	Max	35	38	15	104	68	21

There do not appear to be significant differences in the pre-test scores of the students in the two sections. Test scores improved by about 3-4 points on average for both sections, from an average of 23 to 27 correct responses for the 50 questions. Note however that some of the skills tested were topics such as reading scales, which were not covered in this course. Students also required less time to complete the test, with a reduction of about 30%. No significant difference was observed between students who were taught solid modeling strategies first compared to students who were taught visualization and principles of multi-view drawings first.

Conclusion

Further studies are suggested to compare different approaches to teaching solid modeling as a mechanism for improving students visualization skills. Use of a standardized test to assess student performance facilitates the comparison of student outcomes at different institutions. Future studies will also look at the different components of the Sorby test to obtain a closer correlation between students' achievements and the nine different skills tested, however, the test scores for this study were not available for the individual questions that tested these different skills.

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Biographical Information

Holly K. Ault received her BS, MSME and Ph.D. degrees from Worcester Polytechnic Institute in 1974, 1983 and 1988 respectively. She has worked as a Manufacturing Engineer for the Norton Company and Product Development Engineer for the Olin Corporation. She is currently Associate Professor of Mechanical Engineering at Worcester Polytechnic Institute and has been a co-director of the Assistive Technology Resource Center at WPI since 1999. In the fall of 2001, she was invited as the Lise Meitner Visiting Professor, Department of Design Sciences, Lund Technical University, Lund, Sweden. Her primary teaching and course development responsibilities include undergraduate and graduate level courses in computer-aided design, mechanical design and rehabilitation engineering. She served as the Director of Liaison for the Engineering Design Graphics Division of ASEE from 1995-8 and EDGD Program Chair for the ASEE Annual Conference in 2002. Her teaching and research interests include computer aided mechanical design, geometric modeling, kinematics, machine design and rehabilitation engineering. She is a member of ASME, ASEE, SWE, ISGG and RESNA.