Engineering Design Graphics Journal (EDGJ)
Fall 2012, Vol. 76, No. 3
http://www.edgj.org

ISSN: 1949-9167

Use of Technology Solutions to Improve CAD Instruction

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Introduction

Engineering Graphics curricula have changed dramatically in the past three decades. In the past, students in nearly all engineering disciplines were instructed in manual drafting and descriptive geometry. Students spent many hours “on the board”, and this training enhanced the students’ graphics communication, design and visualization skills (Connolly, 2009; Mohler, 2006). With the advent of CAD in the 1980s, graphics instruction shifted to use these new computational tools. CAD instruction shifted to focus on procedural knowledge, i.e. the ability to use the ‘features and functions’ of any given CAD tool. These curricular changes have been driven by industry’s desire to increase productivity, at the expense of developing good design skills (Brown, 2009). In addition, accreditation agencies in the US have eliminated graphics from their list of required skills for all engineering disciplines (ABET, 2012). As a result, a majority of universities often find it difficult to devote a significant amount of time to CAD instruction in the curriculum. Despite this, increased product complexity and challenges in modern product development means that an understanding or awareness of these technologies is a necessary skill for engineering graduates (Branoff et al., 2002). However, effective use of CAD systems requires the development of declarative and strategic knowledge such as selection of solid modeling alternatives and use of modeling constraints (Chester, 2007; Menary, 2011; Rynne and Gaughran, 2012).

This paper explores the use of a web based Learning Management System (LMS), coupled with Pro/FICIENCY, a PTC (2012) technology designed to automate the assessment of student assemblies, parts and drawings, in an attempt to make more faculty and student time available to focus on strategic knowledge and conceptual understanding that may be more relevant to a wider engineering degree. This paper records student perceptions of using an LMS to understand basic CAD competencies and identifies that there is a lack of conceptual assessments available to adequately understand the impact on their wider education.

ISSN: 1949-9167

Method

The advanced CAD course at WPI is an elective course for juniors and seniors in mechanical, manufacturing and aerospace engineering. The 3-credit hour equivalent course includes 14 one-hour lectures and 14 two-hour lab periods. It is expected that students have taken the introductory 3-credit CAD course and are familiar with solid modeling methods and strategies as well as basic drawings and assemblies. The introductory course is taught using SolidWorks (2012). However, the advanced course utilizes a different software tool, PTC Creo (2012), so the first few classes and labs are devoted to “getting the students up to speed” on the new software and reviewing solid modeling fundamentals, which many of the students have forgotten since taking the freshman course. The remainder of the course covers advanced design and analysis topics such as mechanism design, rapid prototyping and finite element analysis. Students are assessed using modeling exercises, online multiple choice and short answer quizzes, and two or three project activities.

Typically, the lectures cover conceptual material such as modeling strategies, constraint theory, mechanism design, and structural analysis fundamentals. Lab modeling exercises were based on tutorial texts such as (Toogood, 209; Kelley, 2008). Students would complete the textbook tutorials during the lab period with instructor and teaching assistant (TA) present to answer questions, and then complete one or more similar exercises for lab homework, to be checked off by the TA during the following lab period. Experienced lab proctors were available to answer questions during open lab hours outside of class time.

In the case of student work, Pro/FICIENCY can be deployed in conjunction with web based learning management system in an effort to automatically assess variations and mistakes in the modeling methods prescribed by the instructor. The quizzes and parts can be corrected and graded automatically to provide feedback to the students, thus enabling the lab activities to reflect the “inverted classroom” strategy (Gannod, 2007; Lage et al., 2000; Steif, 2009; Toto and Nguyen, 2009; Young, 2012). In this course offering, only the online quizzes were utilized; students were required to complete the tutorial and quiz before lab. During the lab periods, the students were then given more challenging parts to model, which had previously been assigned as homework for the labs. With the inverted classroom strategy, the instructor and teaching assistant were available to assist the students with the more difficult modeling exercises during the lab period. In most cases, these exercises could be checked off during the same lab period.

Results

Upon completion of the course, students were queried to evaluate their perceptions of the use of the LMS tutorials. This is an excellent pool of students to survey, as they used the textbook tutorials for their introductory CAD course, and thus were able to make a good comparison between the two instructional methods. Twenty-three students

ISSN: 1949-9167

completed the survey. In general, about 2/3 of the students stated that they always completed the tutorials before the associated lab session (Figure 1). This is not totally consistent with the data collected from the LMS system, which suggests that the students were not as diligent as they claimed.

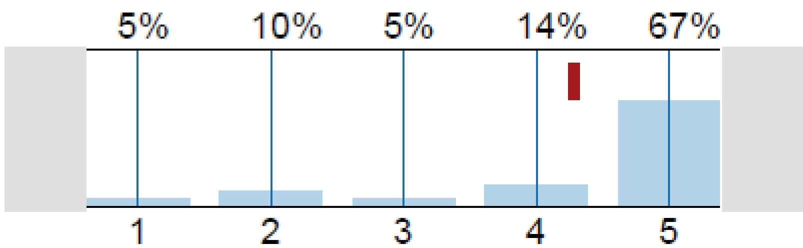

Figure 1. Student completion rate for online tutorials, n=22 (1=Never, 5=Always).

Students rated the LMS tutorials as average, however, three-fourths of the students stated that they would **not** prefer a tutorial text over the LMS online tutorials (Figures 2 and 3). The reasons for this preference were not investigated. This topic will be explored further in future course offerings.

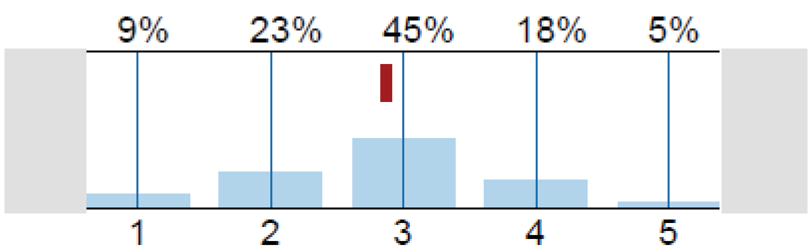

Figure 2. Student rating of online tutorials, n=23 (1=Poor, 5=Excellent).

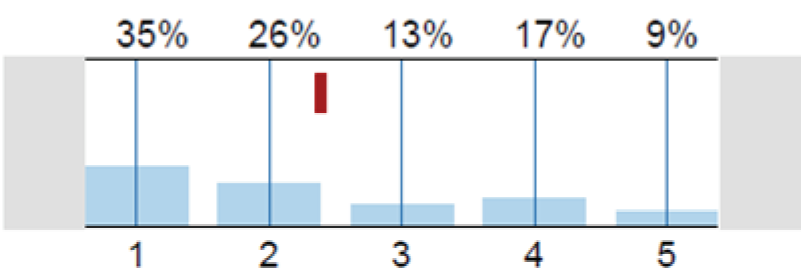

Figure 3. Student preference for textbook tutorials, n=23 (1=Strongly prefer online tutorial, 5=Strongly prefer textbook).

Forty percent of the students felt that the online tutorials helped them to be more productive during the lab periods (Figure 4), and another quarter of the students felt that there was no difference between the online and text-based tutorials in terms of productivity. A significant number of students (39%) expected that they would use the vendor website during the coming year to access additional tutorials for further learning

(Figure 5). Most likely these were juniors who plan to use the CAD software for their capstone design projects.

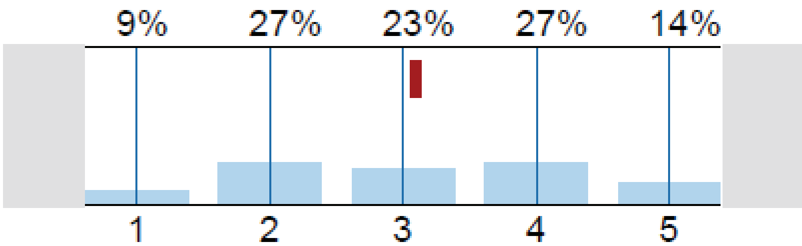

Figure 4. Student measure of online tutorials' ability to increase lab productivity, n=22 (1=Poor, 5=Excellent).

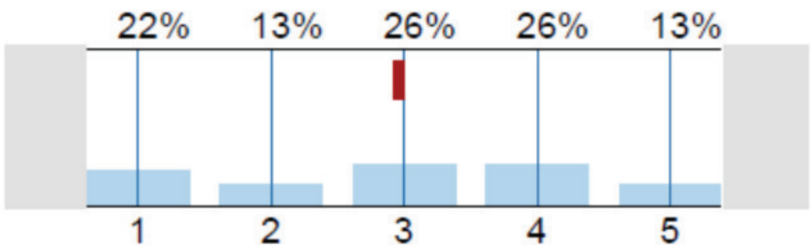

Figure 5. Student prediction to use online tutorials after course end, n=23 (1=Highly Unlikely, 5=Definitely).

Conclusions

Our preliminary results suggest that use of the LMS was successful and resulted in similar outcomes as compare to the use of tutorial texts. Furthermore, students preferred the online learning system, and recognized advantages to be able to access the learning modules for more advanced topics later in their academic program. Future work will focus on the use of the model checking software to reduce instructor grading time and provide feedback to students on modeling strategies.

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