Drafting Project with Design Intent to Improve the Application of Dimensioning Specifications

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Abstract

Teaching first-year engineering students graphical communications has highlighted a specific issue: a lack in their ability to apply dimensioning specifications to open-ended design problems. Students will need that skill in order to properly and effectively, describe any engineering solution that they might develop in the future. This paper describes an attempt to engage the learner by involving them in a design exercise where they are required to provide a detail solution to a problem of their choosing. It is proposed that by allowing the students to invest effort and time in a project of their interest, it will yield better results as they apply dimensioning to describe their personal design.

Introduction

At Embry-Riddle, the objective of EGR120, Graphical Communications, is to provide students with the basics of visualization, dimensioning, and computer-aided drafting that is fundamental to be successful as engineers. These topics form the basis of design expression, which is, the output of much their work.

Currently, EGR120 provides a strong foundation for these areas, achieved by continually providing exercises that reinforce these underpinning concepts. This structured lecture model is heavily framed by the traditional approach of: repetition during class, lab time, and homework provide continuous exposure to new topics. Over time, the course topics combine to create the comprehensive picture required for the completion of the course capstone design project.

One aspect that is of particular interest is the student's application of the abilities learned in class to specific design solutions. This is done through a final project that gathers the material learned in the course into a larger exercise. In an effort to improve the application of knowledge acquired, the final project is split into two parts. The first half of the design project is open ended, students are asked to create a complete 3D assembly of an object of the their choice. For the second half, the students are provided a set of pre-designed and pre-sized parts. These form an assembly, for example, last semester the product was a vise grip. The assembly is modeled in

CAD and the correct set of drawings is produced as output to this section of the project.

This format, while providing the basis for good skill application, has highlighted an important issue: the student's struggle with the application of specific knowledge, in particular the application of dimensioning specifications, to new open-ended design problems.

Purpose

The struggle to adapt to open-ended solutions must be addressed in the course. With a pre-defined problem, students spent a lot of their time just trying to replicate the problem given rather understand the design intent of it. At this stage, it is posited that the lack of the involvement in the object's design is the reason for this struggle. It is proposed that a personal project, chosen and developed by the students, could help them addressed any uncertainty in its creation.

There has been a previous attempt to create a set of dimensioned drawings for a design chosen by the student. At the time, the main problem that arose was the scope of the design chosen. Often, the student choice was too large given the time allowed during the semester. For example, a student tried to model a full motorcycle but it was so large that he found it too overwhelming to cope even with just a portion of it. There is clearly a need for evaluative or formative assessment during this process to build and correct the student's skills as they approach the end of the final project.

To fully realize the idea of an open-ended design from concept to drawing set, the capstone project will change from one final larger exercise to one that would span throughout the entire semester. This would provide appropriate instructor supervision, feedback and guidance at the critical design stages and guidance up to the creation of the CAD models and dimensioned drawing set. With more focus on the design portion, it is expected that the learner's inside knowledge of their own design solution would lead to a better application of drafting and documentation of their concepts. An example of this is dimensioning. Students often have difficulty with properly setting up dimensions on parts given to them since they not always fully understand the purpose of the product. If the project is their own, they would not be trying to deduce how it was made but rather, as it is desired, they would be able to show how it should be manufactured.

This type of internal knowledge of design is also used on other skill learning courses, such as programming. In that case, understanding the complexities of a problem is a necessary aspect to the critical thinking skills required to apply appropriate solutions (Wright, 2007).

Design

The class is taking place during a six-week summer term and two sections are being taught. The total number of students is 34 and for the majority of them it is their first university course, though they are not all incoming freshmen. Twenty-four of them are high school students that are enrolled during this summer term prior to their senior year. However, there is no difference in the content of the course from a regular semester.

To manage the scope of the project, a single problem is chosen by the students but it is approved by the instructor prior to start of the project. The assembly must contain at least 8 distinct parts (though they may repeat) that must be modeled, dimensioned and finally assembled into the final product.

The course-long project will also have multiple milestones. These intermediate markers would allow timely feedback from the instructor in regards to the scope and appropriateness of the design choices. This constructive feedback will have a formative quality that will enable to the students to develop the final project by following design intent and with the understanding of their own design (Leahy, 2012). The four milestones are:

1. Present a proposal for the product to be designed. This should be a small set of both hand sketches and a small report that shows the overall sizing and configuration of the proposed assembly. A minimum of eight individual parts was required.
2. Present the detailed dimensions of each individual part. Again, hand sketches would suffice but the objective is to work out the final size of each individual part of the assembly. Attention would be observed to mating dimensions.
3. Fully realized 3D CAD models of the assembly to show the feasibility of the assembly.
4. Full set of dimensioned drawings for the assembly. Specifically, the final set is composed of:
    1. Isometric of assembly.
    2. Orthographic views of assembly.
    3. Exploded view of assembly.
    4. Parts list.
    5. Dimensioned views of each part.

The students should be able to create a correctly constrained CAD model of each part of the assembly of their product, an assembly of that product to demonstrate that the mating dimensions are correct and fully dimensioned orthographic views of each part.

Results

Collection of results was done through a rubric, provided in Appendix A, that had a specific scoring component for dimensioning. In addition, notes regarding the errors were documented in order to compare to anecdotal data from previous semesters.

There were a total of 13 projects, in groups with an average of three members. Table 1 lists the results by project final score and its relation to the dimensioning score. It appears that the more understanding students have of dimensioning the better their final project grade.

Table 1. Summary of results of dimensioning scores

Dimensioning score %	Project Letter Grade	Number of Groups
Above 90%	A	6
Above 80%	B	1
Above 70%	-	-
Above 60%	B	3
Above 50%	B/C	3

Aside from the score data, the most common dimensioning errors are provided in Table 2. Given that the previous experience was based on observation, this helps with comparison with current results. The errors are grouped in three categories: Missing Dimensioning, which are cases where a dimension is not provided at all, Improper Dimension Location, in this instance the dimension might be there but located incorrectly on the view, and Incorrect Displayed Units, for example displaying feet instead of inches.

Table 2. List of most common errors.

Type of Error	Number of Projects Containing the Error
Missing Dimensioning	8
Improper Dimension Location	6
Incorrect Displayed Units	6

It is worth noting that with exception of one project, most of the errors occurred fewer than 5 times per project.

One of the areas of concern was the completion of the drawing set according to the team's proposal. Every team was able to complete their assembly and corresponding drawing set. At the same time, they accounted for all the parts used in their product in ther drawings.

Completed dimensioning was also an area of concern. One the reasons these changes were attempted, is that students would often not provide dimensions at all. An example from previous years is shown in Figure 1. The assumption is that since the students were given all relevant information about the part, they did not feel the need to fully describe the object that they replicated. In Figure 2, from the Summer 2013, a greater effort in dimensioning is seen on the part of the student. This held true throughout all the projects submitted, even in the worst dimensioning cases the students were still making an effort to fully express the information regarding the part as compared to previous semesters.

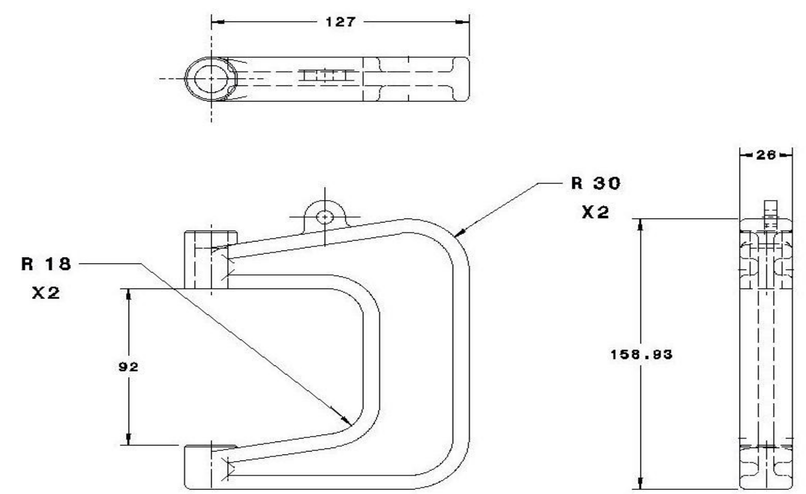

Figure 1. Orthographic view from previous years. Note the significant amount of missing information in the dimensioning process.

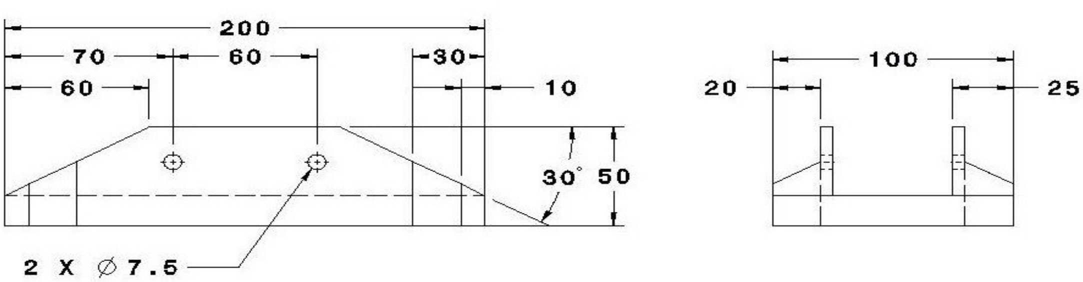

Figure 2. Dimensioned views from Summer term during which the changes were implemented.

While missing dimensions are still an issue, extreme cases, such as the one referenced in Figure 1, did not appear during this term. Cases with a missing dimension or two in a particular view were more common than several missing dimensions in a view. From Table 2, it is worth noting that incorrect dimensioning location ocurred about the same number of times as incorrectly displayed units. While these issues are certainly related to a quality control check, it is not known if the problem was exacerbated by the fast-pace nature of a summer term and bears further investigation. The grounds for this reasoning is that units displayed is a default that can easily be changed in CATIA but is quite often overlooked in some views, in particular when corrections have been made. This leads to the belief that students were rushing to submit the project by the due date.

Conclusions

As students had a higher vested interest in the project, the completion rate of the final project this semester was improved as compared to previous semesters. This semester, every team was able to create all parts and drawings for their project.

The principal conclusion is that students do benefit from the knowledge of the product they are building. An immediate advantage seems to be the reduction of cases that have a significant number of missing dimensions. While this problem has not eliminated but it has been reduced. For continuous improvement, it is recommended that an extra milestone of quality control corroboration be implemented in the future. This milestone will exist just prior to the final submission. The students will peer review each other's work using the final project evaluation rubric as an assessment tool.

Given the improvement seen, this study will continue to be implemented during the upcoming Fall 2013 and Spring 2014 semesters with published results to follow.

References

[1] Leahy, K. (2012). *Promoting best practice design intent in 3D CAD Modelling: Feedback as a constructivist paradigm of teaching and learning.* Department of Design and Manufacturing Technology. University of Limerick.

[2] Wright, D. (2007). *The Decision Pattern: Capturing and Communicating Design Intent.* Computer Science Department North Carolina State University Raleigh, NC USA.

[3] Gerber D. and Forest F. (2011) *Teaching Design Optioneering: A Method for Multidisciplinary Design Optimization.* CIFE Technical Report #TR203 June 2011. Stanford University.

[4] Rynne A. and Gaughran W. (2007) *Cognitive Modelling Strategies for Optimum Design Intent in Parametric Design.* American Society for Engineering Education AC 2007-2132

[5] Tate, Derrick et al. (2010) *Matching pedagogical intent with engineering design process models for precollege education.* Artificial Intelligence for Engineering Design, Analysis and Manufacturing (2010), 24, 379–395.

[6] Condoor, Sridhar et al (2008) *The Art of Design Modeling – Teaching Freshmen*. American Society for Engineering Education AC 2008-2094

Appendix A

Rubric for evaluation of final project.

FINAL PROJECT RUBRIC

NAMES:	______________________________
ASSEMBLY:	_____________/ 10
ELECTRONIC FILES:	_____________/5
ISO, ASSEMBLY:	_____________/5
ORTHO, ASSEMBLY:	_____________/10
EXPLODED:	_____________/10
PARTS LIST:	_____________/10
INDIVIDUAL PARTS:	
DIMENSIONING	_____________/30
VIEWS	_____________/10
PRESENTATION (TITLE BLOCK,	
PRINTING,NEATNESS)	_____________/10
TOTAL	_____________/100