Design Content in a Graphics Course

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Abstract

RIT is a career oriented institute with a long history of close ties with industry. All students in Engineering must complete live coop work blocks. This has two major effects on design content in the curriculum. First, the content must start in the lower level courses to prepare the students for their coop work blocks which begin in their third year. Second, the design content must be truly relevant; coop makes the students mature, demanding customers.

The graphics sequence of three required, and one upper level optional, courses have significant design content. The first year course teaches fundamentals. The second year GD&T and CG courses are project based. This year they were split from a single course to allow transfer students more flexibility; many have CG, few have GD&T.

Both second year courses will continue with design content:

l-Each assigned drawing requires an isometric sketch showing an engineering application of the part. It must be unique, the part is modified to reflect the design use. Therefore, each students' drawing is unique which greatly increases grading time.

2-Students form three to five member design teams and develop a set of drawings for a device. For the past three years the students have produced stereolithography models of their device.

This course is later used in the fourth year DFMA course and in the fifth year Sr. Design sequence where a set of GD&T drawings is a required deliverable. These courses demonstrate that design content really excites students, and that they will put in a great deal of extra effort. They often select projects that greatly exceed course requirements. The only downside is the workload on the faculty.

Need for Early Design Contact

RIT has a very long history as a career oriented educational institute. Many trustees are from industry and the institute has long maintained a close working relationship with industry in general, and Rochester industry in particular. For example, Mr. Jim Gleason, CEO of the well known Gleason Corporation is very active as a trustee. The engineering building is named the Gleason Building and there are two Gleason endowed chairs. IBM had all the engineering and business faculty, and some staff, at their training center for a week of TQM training.

Engineering is a live year program. RIT is a quarter based institution. Engineering for the first two years follows the traditional fall to spring academics with the summer between the two years for vacation, work, or course makeup. The students spend their last three years

alternating cooperative work blocks with academic blocks. Students are split between 'A and 'B' groups so that in any quarter about 50% are working and 50% are in classes.

To prepare students for their first work block after only two years the students must have sufficient training to be useful. This requires an intense course schedule and significant design content. It also means the customers, the student and the employer, get to measure the quality of the education not at the end, but at the midpoint.

Project based design education starts at the freshman year and ends with a two-quarter, team based, capstone Senior Design Project.[1] Students can learn either from bottom up or top down study of design. In the second year graphics course we offer, they have the option of either approach. They can generate a new design or document on existing design. The effectiveness for the latter approach was concerned in a very interesting presentation at the 1995 ASEE Conference.@)

Graphics Sequence

There are three required courses and plans for an optional upper level course. The required courses:

EMEM 211- a freshman course of fundamental graphics. It is a three credit lab course. Students complete large number of exercises from a workbook.

EMEM 312- a second year course that concentrates on Geometric Dimensioning and Tolerancing (GD&T). It is a two credit, project based lab course. Xerox, which has a copier design center in the Rochester area was an early leader in the US conversion to GD&T. Kodak, with a large presence in the area also uses GD&T.

EMEM 313- also a second year course that concentrates on Computer Graphics (CG). It is a one credit, project based, lab course. It was split off of a single three credit second year course to allow many transfer students more flexibility. Many transfer students have very acceptable backgrounds in CG, very few have acceptable knowledge of GD&T.

Design Content

The two instructors for the second year courses both had mid-life career changes to education. I spent fifteen years in the engineering profession at Xerox preceded by four years in the USAF and two years at Kodak. My colleague spent many years at Kodak in various engineering position. We both have a love for design that we have incorporated in our teaching.

Prior to dividing the second year course into two courses the design project was team based with each team member responsible for at least one piece part drawing, and an assembly drawing. They converted their CG work into STL files and that was used by the faculty to produce stereolithography models of the parts. The students then did any necessary shop work to allow assembly.

The leveling device [1] in the text by Earle was chosen as the default project choice. Students were strongly encouraged to select a unique project. They would select an existing assembly drawing, an existing device, or a design concept. Teams consist of three to five members. They self select the team. Part of a lecture is devoted to team selection. They have had permission to share part drawing files to use in preparing the assembly drawing. This, however, never turns out as easy as they have hoped for.

Projects have covered a very wide range of possibilities. Some examples:

Toilet tank dispenser for cleaning solution; bottom up design for new product
Ten speed bike rear derailer; dissection approach with real product
Lock blade pocket knife; dissection, redesign
Air engine; by an ambitious group of fifth year students; dissection, redesign
Timing chain gear set; dissection of scrap assembly
Scotch yoke; prototype build of a text book design
Reading material holder; bottom up design for new product
Brake Assembly; dissection Figs. 1 and 2 (4)

With the split in the second year course the students will work on two projects. In the GD&T class they will develop a set of drawings for an assembly. The drawings can be drawn by hand or CG. The learning goals will be:

l- Team selection, teamwork
2- GD&T reflecting functional requirements
3- Development to an assembly where parts produced to print will work 100% of the time. We do not teach selective assembly until the fourth year

The CG course will also have a project where the part files will be used to produce prototype parts on the CNC equipment.

A Project

An example of a project this year was a standhold reading material while using a stationary bike. It was to stand on the floor with adjustments for height and reading material angle. Students on the team divided the work as follows:

Base
The two adjustable legs
The angle adjustment, which also served to mount the piece the reading material rests on, to the legs
The reading material rest

Standard hardware was not drawn as separate parts but was specified on the assembly drawing. Each student had to draw a unique assembly drawing. They could import team members part drawings.

The assembly for this particular project was very challenging since there were many closely toleranced functional joints. It also required determination of locational relationships for adhesive assembly and press fit assembly.

The first efforts were not at a level acceptable to industry. The drawings received an ample layer of red ink. Then the key step of improvement was taken and the drawings were then subjected to a second round of red ink. This is critical to project based learning. The students must not be allowed to stop at ‘C’ or ‘B’ level work. They must upgrade. This has so much more value compared to seeing a good design developed on the board. It looks so clean and easy when accomplished by an experienced designer.

As analogy: anyone can follow an experienced guide out of the woods; the real learning comes from applying the lectures and demonstrations with ones new compass and map after being dropped in the middle of the woods. Guidance and advise must be available when needed. Office hours become endless. Students must not be allowed to become too “lost” in the woods. They need some clues, but not easy guidance out of the woods. A great deal is learned from mistakes, particularly when upgrades are possible so that the expected learning errors do not impact the grade.

Team dynamics run the range from all leaders to total apathy. In general, after a few early problems, acceptable team dynamics develop. One member shows talent in conquering software problems, another actually understood how to select and specify datoms, another has a computer so they don't have to deal with computer lab hours but can work at student preferred hours in the middle of the night, and another pushes them into working together. Some of the answers to the assessment question of "Who was the most enjoyable team member to work with?" give answers that can almost bring tears to the readers eyes.

The Stand Project group had good team dynamics. They helped each other and sought help in ones, twos and occasionally as a group. They divided work fairly, helped each other, and maintained a sense of humor. They developed individual assembly drawings with unique approaches and unique errors. This is often not the case. Many times the only difference on a teams "unique" assembly drawings is the students name.

Although the stand drawings were far from ready to hand over to a production company for the birth of a new product, they were nicely done. They served the purpose of developing two very necessary engineering skills. One, how to read and develop engineering drawings using GD&T. Two, beginning knowledge of the design process and the interaction of the many courses that make up the education of an engineer.

The Other Design Reauirements

Assignments for drawing other than projects parts require the students to produce on isometric sketch of an engineering application of the part. The grading then reflects this application. The choice of datums, location callouts, tolerances, etc. is reviewed based in the application. It is expected that each application will be unique. The student can add features to the part for the application. The reaction by students to preparation of a unique, creative, solution is very interesting to observe. They are so accustomed to a single correct solution that some have severe problems with this "soft" requirement. As the quarter progresses most students develop confidence in their creative solutions and begin to enjoy a course where their answers are unique and friends can NOT request to copy their solution.

A paper given by P.S. DeJong [5] supports the very high effectiveness of design driven courses that are team based. The projects makes the learning relevant and there is a reluctance to tend to work harder. DeJong states that cooperative learning is effective, and trying to apply his approach seems to confirm that. At the ASEE Conference a few years ago there was a presentation on student group learning that I was extremely impressed with. Unfortunately I do not remember the names of the presentors. I use their technique by giving the design teams in-class problems and the teams compete against each other to be the first to correctly answer a common list of questions. Eveyone gets very actively involved. The hour flys by.

Grading

The laws of engineering govern here. The piper must be paid. Unique solutions make for very slow grading. Each isometric sketch must be reviewed and understood prior to grading. Each students work is unique and this greatly increases the time required to grade and prevents the use of a student grader. The assigned part can be changed as long as it is made more complex. This also slows the grading. Also, since almost all of the projects are different, each must be carefully thought through before grading. There are no answer sheets or posted solutions for this course.

Course Annlication

Students use the course if their coop assignment deals with engineering drawings. Unfortunately, not all assignments deal with drawings. Two upper level courses require retained knowledge of the courses. The fourth year Design for Manufacturing and Assembly (DFMA) reviews GD&T, particularly true position, and teaches statistical tolerancing and selective assembly. The fifth year, capstone, senior design course requires a set of drawings as one of the course deliverables.

Assessment

Assessment is multiphased:

. Immediate by both institue and instructor prepared, end of course, student reviews. The instructor form not only questions the technical content but also the problems and rewards associated with teamwork. Students find teamwork on a unique project to be difficult, and often frustration, but universally a worth while learning experience.

*Higher elvel courses use what was learned in this course as a required skill. The two primary courses are:

1- DFMA requires sketching the redesign and often involves use of project sponsors engineering drawings.

2-Senior Design requires preparation of drawings on a deliverable. Some Senior Design projects involve sponsor preparation of parts to be used in the prototype built. These are made to drwaings prepared by the students.

. Coop employer feedback is an important measure of our courses. We must respond to their changing needs and to their asessment of student preparation of they will stop hiring our students. We must place each student five times prior to graduation and then help the student find a full time job. Coop placement is a very real time assessment of course effectiveness. The EMEM 312 and 313 courses are timed to be taken just prior to the first coop assignment.

. Seniors are solicited for feedback just prior to graduation. After five work blocks and their jub search or graduate school applications they assess their education.

Theses four emthods of assessment can give a range of answers. The course can be perceived similar to a painful medical experience. The first review stating ir was too painful, the later review showing a long term survival rate turning positive. The nice thing about design content is the positive perception of interesting design work at the time and the long termreview showing excellent preparation for unique real world problems.

Conclusion

A high level of design can be successfully included in fundamental engineering courses. Students rise to the challenge and are willing to put a great deal of extra effort into unique design work. The only drawback is the incredible amount of time it takes to grade the work and to meet with students who need extra help.

References

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Bibliographic Information

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