Designing a Design Project

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Abstract

With the current stress on incorporating design throughout the curriculum, many courses that have in the past lacked a design component are being altered to include one or more design experiences. Some courses, specifically upper division, are easier to incorporate design projects because of the knowledge and maturity level of the students. Creating good design projects for lower division courses tends to be more difficult because of the limited knowledge and skill base of the students, lower maturity level and typically over full schedules to cover all required topics. This paper will discuss techniques and suggestions on how to design a good design project with a stress on the lower division courses. Included will be a short discussion of using the ABET design criteria and choosing which aspects of the criteria should be present in a given design project. Following will be suggestions of other qualities that make good design projects such as creating open ended projects, reporting requirements, project definition hints, and designing the project for "easy" grading and evaluation.

Introduction

Incorporating design in both the curriculum and individual courses in engineering and technology is continuing to be stressed. There has been a realization that design experiences need to be presented throughout the curriculum, and are very important in the first years of a technical education. Numerous papers have been written and presented on the importance of design and the importance of including design projects in the curriculum.

Upper division courses allow for easier incorporation of design projects because of the maturity and knowledge level of the students. These factors allow for the upper division design experience to be either very broad integrating many topic areas or very narrowly focused in a specific application of a given technology. In addition, upper division design projects can be either very complex as are many "capstone" design projects, or simpler one to two week exercises. Lower division students are limited in their technical background, skill base, and maturity level. These factors limit the scope of potential design projects to a few topic areas and limited complexity. Creating good design projects for lower division courses tends to be more difficult because of this in addition to the trend that lower division courses have overly full schedules to cover all required topics. This paper will discuss techniques and suggestions on how to design a good design project with a stress on the lower division courses.

ABET Criteria

A good place to start to determine what will make a good design project is the ABET criteria. ABET design criteria[1] is a long list of aspects to be included in a design project including

> "use of manuals, handbooks, material and equipment specifications, and also computers where applicable. Appropriate codes and standards from current industrial practice must be emphasized. Open-ended design experiences which integrate materials, manufacturing, design analysis, graphics, or other topics from prerequisite course work must be included in some upper division courses. Concepts relating to the environmental and economic impacts of design should be introduced."

All the aspects need not, and should not, be present in a particular project. Often, only two or three aspects of the criteria can be accomplished within the time constraint of the project. Longer, more in-depth projects may include more aspects of the ABET design criteria. In lower division courses, the concentration should be in the application of the course technology to a problem and creating a project that is "open-ended". An example of a technology based project might be, in a materials course, to stress the material selection with possibly some cost considerations. In the author's statics course, a truss design project is given with the basic criteria of developing an efficient design where efficiency is defined as load carrying capacity divided by structural weight. Both of these cases can be "open-ended" projects. The importance of being "open-ended" is to inject the realism that there rarely is one answer. In addition, the students can learn from one another from the variety of solutions.

Project Design Considerations

The author has found that the most difficult part of creating a good design project is to come up with the project problem. Many problems exist in the real world but are too complex or lengthy for a class design project. One must constantly remember that the intent of the design project is to give students an open-ended design experience. Too complex or lengthy a project often shifts the stress from the design process and application of the technology to "get it done". A real life problem can be a source of the basic concept, but the problem may have to be altered or simplified for the assigned project. Realize that what an instructor may consider a realistic basic problem to solve is often a high level problem to freshman and sophomore students. An example is a design problem the author uses in a strength of materials class. The problem is to design a light aircraft strut-supported main wing spar, given a strength and deflection criteria. In the real world this is complex problem with lift, drag and twisting moments. For the class, the problem is simplified in two ways. First, the loading on the spar is simplified to include only lift. Secondly, there is a constraint as to how high and wide the spar may be in addition to requiring a constant cross section along the span. The students are to find an optimal supporting strut location and spar cross section. With thoughtful and observant consideration, many real life problems are easy to find. Many ideas can be obtained during the daily commute by observing what is going on by the roadside, in the news, and in popular press magazines and asking the question "What if?".

ASME, SME, Prizm and other technical magazines are another source of ideas using the latest technologies. Good ideas can also be “borrowed” from colleagues. Another source of problem suggestions is text books. Many text book homework style problems may be altered to design problems by the removal of a constraint or otherwise slightly modifying the problem in other ways such as reversing what is known and unknown.

For lower division classes, it is useful to include construction and testing as part of the design project. This helps reinforce the fact that theory does model reality and engineering practices really do work. In addition construction and test can add an element of competition to encourage good designs. One hazard of construction and test is that the project needs to be craftsmanship independent. Choose projects, materials and construction methods so that the end results are not overly influenced by the quality of the construction.

Once the problem is defined, the next task is to create the actual assignment. Things that must be considered are:

1. specific project problem definition wording.
2 reporting requirements.
3. grading and design evaluation.

Each of these aspects should be well defined before the project is assigned. In addition, these items should be defined in specifics for the students. The author typically hands out to each student a detailed 2 or 4 page project assignment. A detailed written assignment avoids many questions, assures the instructor has throughly thought out the project, and avoids students wasting time doing things not required for the successful completion of the assignment. The more detailed the instructions, the more secure the students are in performing their work and the fewer problems and questions there are about the form of the project.

The specific project problem definition wording should be a logical progression from an overall problem definition and gradually work down to specifics. Include diagrams for things that are best shown graphically. As an example, the author’s static truss project first says that the students are to design, construct and test a truss that is 30 inches long and 6 inches high. Then the problem text explains the details of the pack of materials from which the truss is to be made. Next, other constraints are described such as the hole to edge spacing for the fasteners, strength of the material and other details needed for successful completion of the project. Diagrams are given showing how the truss will be tested, and suggested gusset designs. The project definition is given in an order of basic concept, then major aspects to incorporate, and lastly specific details that are needed.

There are two basic reporting methods available, a written report and oral reports. In either case, a professional quality job should be the end product. The only way to get a professional quality report is to be specific in the project assignment as to what is expected. Three types of expectations should be addressed. First, what type of reports, oral and/or written, are required and when. Second, what should the report include. Again, the more specific the definition of the requirement, the lower the student and instructor frustration level. Be specific as to the sections

of the reports and what each section should contain. Give suggestions on the process of creating the report. For formal laboratory reports, the author suggests that the students write the body of report before writing the abstract. Some instructors include a sample report to use as a guide. This is very helpful to freshman students who may never have had to do a report of this nature before. Third, what does the instructor consider a "professional quality" to be? The author requires all reports that have diagrams or drawings must have these drawings produced on a CAD system, graphs produced using a spreadsheet, and all written text produced on a word processor. Using the professional tools not only gives the students experience with the tools but also encourages higher quality work.

The grading criteria and design evaluation criteria should also be specifically defined. Many instructors create a grading sheet while they are designing the project. They often include a blank sheet as part of the project definition handout to the students. Be specific about the grade weight of various aspects of the project. The advantage of creating the grading sheet along with the project definition itself is that grading difficulties can often be foreseen and avoided. If the grading and evaluation aspect of the design project is done in parallel with the project definition, it tends to aid in creating a better overall definition because the instructor's expectations are clearly known and thus can be more easily written and defined than if grading is an afterthought. In addition, considering the grading issue often brings to the forefront the complexity of what is being asked of the students. The author often finds that when he considers grading the project he finds the projects are too lengthy or complex and need to be simplified.

Conclusion

Incorporating design projects in individual courses is important and can be done if attacked appropriately. Ideas for projects are everywhere if one is open and looks at the possibilities. Assurance of a successful experience for both the students and instructors is directly related to the preparation and thought given to the design project before the assignment. This preparation and detail in the assignment improves the communication of the project and reporting expectations, and thus lower stress for students and faculty. Done properly, the design project experience can be an excellent educational experience.

References

1 "Criteria For Accrediting Programs In Engineering Technology", TACO/ABET 1997-98, Section VI.N.2.b.5.

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