ENGINEERING DESIGN FOR FRESHMEN

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prepared for

Drexel University
Gateway Coalition

16 February 1998

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CHAPTER 1

DREXEL'S ENGINEERING DESIGN COURSE FOR FRESHMEN

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1.0 Introduction

This report describes an engineering design program taken by freshmen at Drexel University. The purpose of the report is to document how the program is conducted, graded and coordinated with the humanities program so that others might conduct a similar program, either adopting the Drexel program or adapting it to their special needs. The design program is part of a larger sequence of three courses termed *Engineering Design & Laboratory* (ED&L) *I, II & III* which includes other design experiences as well as computer and physical laboratories. The design program, started as a component of Drexel's E^4 program, has been offered since 1989 in one form or another. It has changed over the years as experience has been gained and continues to evolve. Other schools have explored Drexel's approach and this report has been supported by the Gateway Coalition to provide documentation and support for their efforts.

A unique element of Drexel's freshman design program is its close ties with the freshman humanities courses, HUM106, 107 and 108. Humanities faculty are fully apprised of ED&L design program requirements since they were involved in formulating them and have adapted their humanities courses to support students in the design course. Design is a creative process, not unlike creative writing. Research, clear thinking, exploration of alternatives and revision are common to both good engineering design and good writing. Recognition of this has led to a symbiotic relationship between the humanities courses and the design element of ED&L. Chapter 2, by Marijo Makufka, provides a description of the humanities content of the design experience.

Chapter 3, authored by James Mitchell, gives an overview of how design courses might be structured along with the resources needed to conduct them.

1.0.1 Up-Front Engineering. - A persistent problem in engineering education has been student retention. Most students who drop out of engineering do so during or immediately following their freshman year. Many state that engineering was not what they thought it was, even though they had not yet had an engineering course and many had never spoken with, much less taken a course with, engineering faculty. Students quit engineering without ever knowing what engineering is. Their experience included only mathematics and science courses which were often presented in a way that did not reveal their relevance to engineering. Engineering freshmen exposed to science and mathematics did not have the opportunity to apply their knowledge of science and mathematics to the solution of problems. A design program in the freshman year exposes students to the design process - a fundamental engineering activity. Exposure to design

gives freshmen an opportunity to develop self-discipline and to work on a team project leading to a sense of accomplishment during their transition to university life.

1.0.2 Philosophy of the Drexel Engineering Curriculum (tDEC) The Drexel Engineering Curriculum (tDEC) is an outgrowth of the experimental, NSF-funded Enhanced Engineering Educational Experience (E^4) Program initiated at Drexel in 1989 (Quinn, 1993). The E^4 program sought to expose students to the practice of engineering early in their academic careers. TDEC, the curriculum-wide implementation of E^4, continues to introduce and emphasize engineering from the first day. Engineering is taught contemporaneously with mathematics, physics, chemistry and biology. As students learn science and mathematics, they learn the engineering applications of those tools. Problem solving, the essence of engineering, is taught from the outset using the science and mathematics the students are in the process of learning. In fact, science and mathematics are taught "just in time" for the students to apply the principles to their engineering studies. Because of the engineering content of the freshman and sophomore courses, students are also exposed to engineering faculty early in their academic careers. That exposure occurs as engineering faculty teach ED&L, serve as recitation instructors (and occasionally lecture) in Physical Fundamentals of Engineering I, II & II (PFE I, II, & III) and Chemical & Biological Fundamentals of Engineering I, II & III (CBFE I, II & III), as well as serve as freshman design advisors. Early exposure to engineering allows students to make informed decisions regarding their interest in a specific engineering discipline or in engineering as a career.

The humanities are also integrated into the freshman and sophomore engineering curriculum. Humanities faculty coordinate the content of HUM106, 107 & 108 with the mathematics, science and engineering courses. In addition to the typical freshman humanities course content, students write journals, essays and poetry related to science and engineering. They read about scientific discoveries, the practice of engineering, engineering projects and failures, and address the environmental and social impacts of engineering.

Since engineering studies are begun at the freshman level, upper level engineering courses can be presented at more advanced levels; also, there is room in the curriculum for advanced mathematics and science courses relative to the student's engineering discipline.

At the freshman and sophomore levels, tDEC demands increased coordination among instructional staff. In addition to meetings of the faculty involved with a given course, weekly coordination meetings of all freshman and sophomore faculty are scheduled. Students are invited to a portion of each weekly meeting to ask questions, express concerns and to request actions of the faculty and program coordinator. Student workload is routinely assessed at these meetings so that adjustments can be made to examination schedules, project deadlines and other demands on the students' time.

1.0.3 Engineering vs. Science - Problem Solving vs. Pure Intellectual Inquiry - Engineering and science are different. Knowledge of science, however, forms a very important

component of engineering. (In the present discussion, the term science is meant to include applied mathematics) Generally, science is the study of a topic to develop understanding: understanding of processes and the properties of materials. Engineering represents the application of this understanding of processes and properties to the solution of problems - usually with a view toward improving the human condition. Engineering design involves decision making. The eventual result of engineering design is a decision to either pursue an opportunity or to abandon it. The design process is a sequence of decisions about how to proceed in order to attain objectives considering the constraints under which those objectives must be achieved.

1.1 Logistics of the Design Course

1.1.1 Overview of Course. Freshman design at Drexel is taught as part of a 3-quarter sequence of courses entitled Engineering Design and Laboratory (ED&L). The three courses, ENGR130, 131 and 132, are taught in the fall, winter and spring quarters respectively. Four design-related activities are included in the courses: a first-week design competition, a "specification sheet" project, a "how it works" project and a comprehensive team design project that bridges the winter and spring quarters. The first-week design competition is a team project while the "specification sheet" and "how it works" projects are done individually. These initial design projects are completed in the fall quarter in ENGR130. The freshman design experience is capped by the two-quarter team design project which is the subject of this report. The student's ED&L grade for the winter quarter (ENGR131) is determined by the team's performance on the design project. The winter quarter grade is held until the design project is completed in the spring term.

Engineering design represents only one of three major elements in the ED&L sequence. Each quarter of ED&L is 4 credits for a total of 12 credits. The design project comprises about one third of the student's grade in the three courses or 4 quarter credits. The other elements include a computer laboratory which covers scientific, mathematical, engineering and general purpose software use, and an extensive "hands-on" laboratory experience which teaches physical, mathematical and engineering principles through experimentation. This portion of the course includes data collection and analysis, and the interpretation of the experimental results.

The freshman design program is managed by a course coordinator who is responsible for organizing the course, presenting lectures, insuring that design teams are formed, identifying design team advisors, and insuring that design teams have secured a technical advisor and are aware of course requirements and deadlines. Design team grades are assigned by the individual technical advisors with whom the design teams meet regularly for guidance and advice. The technical advisors work closely with each team and best know their work. The coordinator, however, establishes grading policies and suggests weighting factors for the various deliverable components of the design project. In the past, advisors have been asked to submit only a single final grade for a design team which encompasses the sum total of their project work. Early attempts to solicit grades for the individual deliverables produced by the teams were burdensome for the coordinator since there were about 100 design teams distributed among

25-30 faculty advisors. However, new assessment instruments have been developed and will be tested in the 1997-98 academic year. These assessment instruments are described later in this report.

1.1.2 Formation of Design Teams Design teams are normally formed by the students themselves. In unusual circumstances teams may be formed by the course coordinator or students may be assigned to an existing team. Students are encouraged to discuss their interests with classmates and to discuss design topic ideas. They are advised to seek teammates with whom they can work and discouraged from forming teams with friends with whom they spend their leisure time. Many students ignore this advice and form teams with friends. Often teams of friends work, but in many instances students later express regret at not having heeded this advice. Practically, students are advised to find team members from their same HUM107 section to facilitate scheduling team meetings. Students on the same schedule can more easily find common blocks of time to work on their projects. Drexel, being an urban university, has a relatively large commuter population: students who travel as much as an hour each way to and from Drexel. These students often have difficulty finding time outside of class to meet with teammates. Therefore, commuters are strongly urged to join teams formed totally of members from their HUM107 sections so their schedules coincide. Teams have generally been comprised of 4 students; however, in recent years as enrollments have increased, 5-member design teams have been encouraged.

To contribute a sense of realism in the course, design teams are asked to envision themselves either as a team working for a corporation or as principals of a small consulting firm. The approach they take depends somewhat on the type of project they propose: one-of-a-kind projects such as civil or architectural engineering projects suggest a small consulting firm, while product development projects suggest a corporate design team. In either case, the team is charged with selling their idea to a supervisor or potential client. They are advised that the proposal they prepare is actually a "sales" document to convince a supervisor or client of the team's ability to successfully complete the design, along with an assessment of its economic viability and environmental impact. Why should their company or client support the proposed design effort?

1.1.3 Lecture Content Because of the breadth of the design topics selected by teams, most technical discussion and interaction is between design teams and their technical advisors; however, about 6 hours of lectures are given during the two quarter course. Those lectures address about 12 topics: an overview of the course and its requirements, definitions of design and examples of the design process, a lecture on "brainstorming" along with an in-class example brainstorming session, constraints imposed on designs by technical, social, political and environmental factors, time management and scheduling, and the form and content of the "deliverables" required, e.g. the *Problem Definition*

Statement, *Proposal*, *Oral Presentation* and *Final Report*. In many instances the ENGR131 and 132 design lectures complement and reinforce the lectures students receive in HUM107

and 108. For example, students are taught what engineering proposals should include, how to make oral presentations and how to write final reports in both ENGR131 and HUM106; however, the focus in ENGR131 is on technical content while the focus in HUM106 is on identifying the audience and learning how to write and speak to them.

The material which follows outlines the content of the lectures. The material is delivered in about 6 hours. The sequence in which it is presented in the report approximates the sequence in which it is presented in the lectures. The material in the boxes is taken from transparencies used in the lectures.

1.1.3.1 Lecture Topic 1: Overview of Course - While many of the course requirements are documented in the syllabus for HUM106, 107 & 108, the details of how the course will be conducted and graded are given in the first ENGR131 lecture. See Box 1. This first design lecture is presented toward the end of the fall quarter (during the 9th or 10th week) prior to the December holidays so that students can think about and explore possible design topics during the break. "Deliverables," the *Problem Definition Statement*, *Proposal*, *Oral Presentation* and *Final Report*, are discussed and the established deadlines for submission stressed. As in engineering practice, deadlines are generally not negotiable and are extended only in unusual extenuating circumstances.

BOX 1

FRESHMAN DESIGN CLASS - First Lecture (November)

OVERVIEW OF COURSE

1. Selecting a Design Project
- Think about it over the holidays.
- What do you use that needs improvement?
- What problems do you see around you?
- When Uncle Charlie asks you "How's school?" bring up the subject of design and ask for suggestions.
- Solicit suggestions from design faculty.

2. Form Design Team
- Generally 4-5 members with same interest in selected design project.
- Try to get members from same Humanities recitation section.
- People who you can work with (not necessarily friends).
- People whose expertise/experience complements that of others on team.

3. Selecting a Faculty Advisor

- You will be given a list of engineering and science faculty who have agreed to serve as advisors. (Some of them will have suggested certain design projects they are interested in having freshmen work on.)
- It's your team's responsibility to contact a faculty member and recruit him/her to be your advisor.
- You will have to report who your advisor is.

4. The Course
- Classes next term will present information on the design process and how to do it.
- Don't fret about your level of engineering knowledge at this time - you will be surprised at your and your design team's performance!
- That's what advisors are for!! To help you to explore your unrecognized abilities.

5. "Deliverables"
- *Problem Definition Statement*
- *Proposal*
- *Design Conference - Oral Presentation* of design project (dates in late April). You may invite parents, friends, Uncle Charlie, etc.
- *Final report*.

1.1.3.2 Lecture Topic 2: Definition of design - One lecture is spent describing the design process, how it works, its iterative nature, the difference between analysis and design, the role of analysis in design, the role of judgment, and the importance of design review to bring the judgment of others with experience and alternative viewpoints into the process. This material is discussed during the first lecture in the winter term. (See Box 2.)

BOX 2

DEFINITION - DESIGN

Design is the process of identifying and solving problems or achieving a desired objective or objectives by: a) proposing one or more alternative solutions; b) evaluating those solutions in view of physical, economic, environmental, and other constraints; c) adopting or adapting elements of the best alternatives, and d) finally formulating the solution that best meets the desired objective or objectives. Good design is an iterative process.

Analysis is an important tool by which various designs, or elements of a design, can be objectively evaluated. Analysis brings technical knowledge to bear on the evaluation of alternative designs.

Judgment is another tool for evaluating candidate designs or elements of a design. Judgment, however, is not totally objective because it depends very much on a designer's experience. Different designers may interpret objectives and constraints differently. Therefore, no two designers approach a problem in exactly the same way and, in general, will not arrive at identical designs. There are always tradeoffs in design, and judgment is the factor that selects from among those tradeoffs where no quantitative analytic procedures or criteria exist.

Because judgment is not objective, *design review* is an important element of the design process. Design review brings the experience and judgment of numerous designers to bear on a problem. The criterion for evaluating a design is how well it achieves the desired objectives within the given constraints.

Public participation is important throughout the design process for any public works project, initially to insure that objectives and constraints are clearly defined, and later to insure that the original objectives are still valid and have been met within the given constraints. Public participation throughout the design process can also be important in obtaining public acceptance of a project.

1.1.3.3 Lecture Topic 3: *Problem Definition Statement*- In the past, *the Problem Definition Statement* was called an "abstract." It was intended to be a simple statement of the team's proposed project; however, the term "abstract" misled students who interpreted it to be an overall summary of the project. Recognizing that the first and often most difficult part of design is to carefully define the problem to be solved, the abstract evolved into a *Problem Definition Statement*. What is the problem the design team hopes to solve? What solution(s) currently exists, if any, and how will the proposed design improve the present situation? What are the constraints on the solution - technical, economic, social, political, environmental, etc.? Students are urged to succinctly write down the design problem topic, the constraints and the criteria by which the design will be judged. The act of careful writing is one of thinking and defining. Recognizing this, students are further encouraged to write about their design ideas and experiences in their journals for Humanities.

1.1.3.4 Lecture Topic 4: How to operate as a design team -Teams are encouraged to meet at least weekly with their advisors to discuss progress on their design as well as to discuss other problems. The advisor serves as both a source of technical information and of direction for the team as well as a mentor to the individual team members. See Box 3. Teams are told to solicit advice from their advisor on technical aspects of the design problem, but also on how to function as a team, functional problems the team is having, sources of information and general guidance. Since the advisor determines the grade, students must satisfy the advisor's specific requirements of the team. Teams are told that leadership of a team often changes from team member to team member as the project evolves and as different skills are needed to move the design forward. The importance of

good record keeping is emphasized to document both progress and ideas. Minutes of all meetings, outlining progress and individual task assignments are suggested. Journal writing and keeping research notebooks is also recommended to document new ideas. How to conduct productive meetings is discussed along with the importance of an agenda defining specific decisions/goals to be achieved at each meeting. Establishing and maintaining good communication and coordination among team members is emphasized.

BOX 3

GENERAL TIPS FOR FRESHMAN DESIGN GROUPS

- Try to meet with your advisor once a week for at least 1/2 hour. (Try to meet at the same time each week if possible - it's easier to remember!) Everyone on the team should attend! Don't be afraid to ask your advisor questions!
- Have at least one additional "working" meeting with your design group each week. This meeting should be at least 1 hour long. As critical deadlines approach, more frequent and longer meetings will be necessary.
- Someone should take minutes at each meeting. They should be circulated to all team members. This is a good way to record who is going to do what!
- Never, never leave a meeting without a clear understanding of who is going to do what before the next meeting. It is a good idea to put all assignments in writing so there is no misunderstanding. If you don't know what you are supposed to do, ask!
- Generate a master list of all the things that have to be done in order to complete your design project. This list should be "dynamic" changing as some tasks are completed and as others are added when they come to mind. (Keep a running task list for the project and line out completed tasks and enter the date completed. As the end of the project nears, it will be a good compilation of all the work your group has done.
- Establish contacts inside and outside of Drexel to obtain information. (Working engineers are usually delighted to be asked to contribute their knowledge to student design groups. Recognize, however, that they are not getting paid to help you. Be reasonable and don't make a pain of yourself.)

1.1.3.5 Lecture Topic 5: Team building, team work, assigning responsibility - Administratively, the most time consuming element of the freshman design program involves dealing with dysfunctional teams. Most design teams are assembled by the students themselves with only guidance from the faculty coordinator. Students are advised to carefully select team members from among their classmates. They are discouraged from selecting team mates based solely on friendship. Rather, they are encouraged to investigate a potential team mate's expertise and interests and to assemble a team based on these factors.

Teams are advised on how to operate as a team. The importance of communication, coordination and clear work assignments for individual team members is emphasized. Weekly or more frequent team meetings are recommended in addition to a weekly meeting with the faculty advisor. Record keeping and documentation of meeting proceedings is emphasized. One student is appointed to take minutes. Often, one student assumes leadership for one phase of the design project; another student may assume leadership during another phase. Assignments are usually rotated among team members. Clear communication among team members is important. Meeting minutes should include clear work assignments for individual team members so that everyone knows what they are to do prior to the next meeting. Equal participation by all team members is important. Failure of one or more team members to participate fully in the work of the team is the most common complaint raised by dysfunctional teams. Occasionally, the individual who is not participating fully is not at fault; rather, he or she may not have been brought into the team's deliberations. They may not have been advised of meetings or meeting times may have made their participation difficult. Often a student who, for one reason or another, has been assigned to a team (rather than selected by the team) will have this problem.

Diversity and various personality types are discussed in Drexel's ENGAS100, *Introduction to University Life* course. An abbreviated Meyers-Briggs-type test is sometimes administered to and self-evaluated by freshmen. The characteristics of the various personality types are discussed. Design teams are encouraged to seek complementary personality types in order to bring some breadth in perspective to their team.

Usually, the most critical problems encountered by teams are not technical problems but "people problems." Failure to coordinate, unfulfilled expectations of teammates, individual differences of opinion, strong personalities versus more timid individuals, all contribute to problems. Fortunately, these problems, experienced by almost all teams to some degree, usually decrease as the teams gain experience and team members get to know one another.

1.1.3.6 Lecture Topic 6: "Brainstorming" - "Brainstorming" is discussed early in the course and teams are encouraged to use the process to address various components of their design. See Box 4. Among other things, brainstorming can be used to define the design problem, to identify alternatives and to identify constraints. An in-class exercise/ demonstration is used to illustrate the process with a volunteer design team selected to "brainstorm" their project. Their design topic is posed in a very general way and the ground rules for the process explained. Team members are to suggest possible solutions to the problem which is written on a flip chart. (A blackboard can be used but a flip chart provides a more permanent record that can be retained and used at subsequent sessions.) Each member, in turn, is asked to suggest a solution - no holds barred - and the process is repeated beginning with the first team member. An individual may "pass" if he or she has no new idea; however, the process continues until all team members have run out of ideas and everyone has passed. A team member who has passed can reenter the process again when it is his or her turn. Often, an idea expressed by one team member triggers a new idea by another. Each idea is expressed in a word, a few words or, at most, a

sentence. A recorder, who can also be a participant, writes the descriptive word or words on the flip chart as they are being generated. No discussion or criticism of any idea is permitted at this stage. Criticism, or the fear of it, stifles the free thinking process. Often what sounds like a crazy idea at first becomes reasonable and viable when later explained. When the team has run out of ideas, the brainstorming part of the process stops. (However, that is not to say that new ideas are not welcome. They can be admitted at any stage!) The next step is to define what was intended by the word or words contributed by each team member. Each member is assigned to write a few sentences or a short paragraph about each contribution explaining what he or she intended. Most often the person suggesting the idea is best able to describe it. At this stage some discussion invariably occurs and ideas benefit from the additional insight of other team members usually in the form of a clarification. This usually ends the first meeting of a brainstorming exercise.

Each paragraph is given to the recorder who prepares a document listing them. Often at this stage, ideas can be sorted into various logical groups having similar characteristics. The idea document is circulated to the participants who are asked to assign a priority to each idea. Usually three priorities suffice: 3 = good, worth putting out additional effort to develop the idea, 2 = acceptable, worth pursuing if resources permit and if category 3 ideas do not pan out, and 1 = not worth following up. Ideas can then be scored and ranked. A second meeting is necessary to discuss the results. At times, additional discussion and clarification leads to a change in priority. **At this point it is important for the team to decide on a course of action and to identify and assign tasks to begin the design.** Brainstorming is only a beginning and not an end in itself.

BOX 4

"BRAINSTORMING"

GETTING STARTED - It is assumed that you have your design group established and have a rough idea of what it is you want to design.

- **"Brainstorming"** Get your group and advisor together and "think out loud" about your design topic. Everyone gets a turn to contribute ideas and you should continue until you run out of ideas. As you come up with them, have one of your team members write the ideas on the blackboard so everyone can see them. Sometimes they will trigger new ideas. Ideas should be stated briefly so they can be summarized in two or three words. At this stage, no discussion or criticism of any idea is allowed. Discussion and/or criticism inhibits participants and stifles the brainstorming process. Later, after the brainstorming exercise, you should clarify the ideas by writing one or two sentences about each idea. (Usually the person who first suggested the idea is best able to clarify what he/she meant). This can be done after the brainstorming session. Give everyone a couple of ideas to write about. Discuss them at your next meeting.

After each ideal has been described in a sentence or two, discuss, refine and prioritize them. The chances are that low priority ideas are not worth pursuing.

What to brainstorm.

- Step 1 - *Define the problem* you are hoping to solve. Create a "problem statement;" put your problem in writing. Refine it by brainstorming. What are the desirable characteristics of an optimum (best) solution? What makes it the best solution?
- Step 2 - What *skills* do you need to know in order to formulate and refine a solution? Electrical engineering skills, chemical engineering skills, physics, chemistry, etc.? Where can you learn what it is you need to know - or find someone who knows?
- Step 3 - What *data* do you need to formulate a solution? Traffic counts, rainfall data, properties of a material, characteristics of an amplifier, etc.? Does the data exist and where can you find it?
- Step 4 - What *constraints* will you have to consider in your design? There are always constraints that must be considered. There is never enough money or time. People may not like an idea or project, or may be unwilling to buy a new product unless it meets certain conditions. Economic, safety, social, political, aesthetic (appearance), legal and environmental concerns are examples of factors that can impose constraints on a design.
- Step 5 - What kind of *analyses* must you do to demonstrate that your design solves the problem?

When you have addressed each of these questions, you will have a long list of all the elements of your design. These should be addressed in your proposal. (You want to demonstrate how much you know about the subject!) Buried in that mass of paper, if you organize it, is even an outline of your final report. A proposal is simply a statement of the problem you want to solve, how your solution will satisfy the objectives set forth, how you plan to go about solving it, what constraints you are working under, how much you are going to charge your client/funding agency in order to do the design, and why your group should be selected to do this design instead of someone else - your and your design team's qualifications. More detailed information on the format and content of the proposal is in the Humanities syllabus.

1.1.3.7 Lecture Topic 7: Time management - Time management is discussed in the context of design projects being open-ended with only self-imposed limits on the time spent on them. Poor time management appears to be a major factor leading to poor academic performance by freshmen. One criticism leveled at the freshman design program by both students and faculty has been the time demands it imposes on freshmen. Faculty complain that during the period when teams are preparing oral presentations their other studies take second priority. The same problem arises when final design reports are due. Students are advised that they need to develop a sense of when significant additional

work on a project will only bring marginal returns and to strike a balance between design project work and their work in other courses. To address these concerns, mathematics and science content is emphasized in the oral presentation and final report. The team's grade is based in part on the presence of mathematical and scientific analyses in the presentation and report. The design project complements the mathematics and science courses rather than competes with them.

1.1.3.8 Lecture Topic 8: Record keeping - This lecture builds on the discussions of Lecture 4, How to Operate as a Design Team. The importance of keeping notebooks and other documentation of design work, especially for projects that could lead to patents, is emphasized in this lecture. On one occasion a lecturer from the University's Research Office was invited to specifically discuss patents and their documentation requirements. He discussed the patenting process and the importance of recording potentially patentable ideas in a bound notebook with sequentially numbered pages. The humanities faculty require journal entries periodically which address the design team's project, and most advisors require minutes of design team meetings which document decisions and outline work assignments. Records that a design group or firm might routinely collect such as time sheets (manpower records) and data on costs associated with preparing a design are mentioned along with how they migh be important when preparing future proposals. In the humanities component of the course, engineering faculty are invited to present their experiences relating to how important good writing and record keeping is.

1.1.3.9 Lecture Topic 9: Scheduling - The concept of scheduling as a management tool for a design project is introduced. In addition, the individual tasks which typically comprise the design process are identified in this lecture. An example time line (Gantt chart) schedule is constructed. EXCEL and Claris Works versions of the generalized Gantt chart are available to students on the ED&L web page and file server where they serve as a starting point for the teams' project. (See Box 5.) Tasks typical of most design projects are identified. They include: conducting background research using the library, internet, personal contacts and surveys; brainstorming; identifying alternatives and constraints; obtaining data; performing analyses; preparing the problem statement, proposal, oral presentation and final report, etc. Figure 1 list the tasks. Teams are asked to determine the sequence in which they will most likely start tasks and to identify tasks that must be done sequentially and those that can go on concurrently. They are asked to estimate how long they will have to spend doing each task and advised that their initial estimates will invariably be wrong either because of unforeseen circumstances or their lack of experience in estimating how long it takes to conduct the tasks. Fixed deadlines are noted on the chart and teams work backwards from the deadlines to develop their schedule for the design. The schedule becomes part of their proposal. Teams are asked to use it as an initial design process plan but also as a working document which is revised periodically to track progress, always with a view toward meeting impending deadlines. Revisions are made in response to new information, to accommodate unforeseen problems and in response to changes in their project's direction.

BOX 5

SCHEDULING

As a part of your design project proposal, you are required to include a "time line" which shows how you will progress toward completing your project. A "time line" is simply a proposed schedule based on your "best estimate" of what the necessary tasks are, when you will do them, how long it will take you to complete them, and what your deadlines are.

Scheduling is an important part of any design project. It arises in two different contexts: the schedule that lays out expected progress in conducting the design itself, and the schedule for realizing the design - actually building what has been designed or manufacturing it. In this course we are more interested in scheduling your expected progress through the design project. The schedule which informs your supervisor or clients (your technical advisor and humanities instructor) of how you plan to conduct the design process should be included in your proposal.

Gantt Chart

One of the simplest, and yet informative, ways of presenting a schedule is termed a Gantt Chart, named after its developer. The Gantt Chart is simply a list of all the tasks necessary to complete a project arranged sequentially followed by a horizontal timeline bar. The timeline shows the scheduled start of each task and its anticipated completion by a horizontal bar starting when the task is to begin and ending when it is supposed to be completed. See Figure 1.

There are several elements to successfully constructing a Gantt Chart for a design project: a) identifying the tasks necessary to complete the design, b) estimating the time required to complete each task, c) determining if there is a sequence in which the tasks must be scheduled, and d) identifying deadlines.

Identifying Tasks

Carefully think about all of the tasks necessary to complete your design and list them. For example, a generic list (in no particular order) might include:

- conduct literature review (library research),
- make personal contacts (information gathering),
- prepare proposal (write),
- obtain necessary data,
- analyze data,
- identify alternatives

- formulate preliminary design,

- evaluate alternatives,
- prepare final report
- identify design topic,
- prepare final design,
- assemble design team,
- prepare presentation
- rehearse presentation
- revise presentation,
- make presentation,
- prepare draft final report,
- revise final report, and
- submit final report

Identifying the Time Sequence

It is obvious from looking at the above list that some tasks must be completed before others can begin. You cannot write your proposal until you have identified a design topic. Similarly, you cannot rehearse your presentation until you have prepared it. It is also obvious that some tasks are really deadlines, i.e., "make presentation," and "submit final report." It is easy to locate these on the Gantt Chart since they are usually specified by your client or supervisor. They are usually identified by a large asterisk on the chart at the time when they are due.

The remaining tasks can be arranged in approximately in the order in which they must be logically started. For example, the generic tasks listed above are given in order on Figure 1.

Estimating Task Duration

Most of the tasks on the list will require some time to accomplish. Estimating the amount of time necessary depends quite a bit on experience. Some students tend to underestimate how long it will take them to do anything! Others overestimate. In the absence of experience, be conservative but realistic! Remember you have non-negotiable deadlines to meet. Anticipate problems and plan accordingly!

Constructing the Chart

A typical Gantt Chart is shown in Figure 1. The tasks are listed approximately in chronological order and a horizontal time line is constructed. Deadlines are indicated with asterisks. Usually, open bars of the appropriate length are used to indicate the duration of the task. (Open bars are used so they can later be filled in to indicate progress.) The bar begins when the task is scheduled to start and ends when the task is expected to end. This is where a lot of judgment comes into play! Some tasks can overlap

and can be worked on simultaneously - after all, there are several team members - other tasks must await completion of an earlier task. For example, you can be writing some parts of the final report while you are completing the final design, but you can't revise your report until it has been written and reviewed.

Using the Chart

The Gantt Chart can be used in at least two ways: as a proposed schedule (in your proposal), and as a progress chart as you carry out your design. It can also serve to identify what resources are needed and when they are needed. For example, if an entry on the chart is "analyze data" it implies that the data will be available for analysis! You might also look at the chart to see when extra manpower is needed to meet a deadline, e.g., writing and preparing figures for the final report.

The chart should be referred to as your project progresses to insure that you are on schedule. Obviously, things change! You can't have anticipated everything that occurs as you move through your design project. If things change, update your schedule, but remember that your deadlines are fixed!

The chart can also serve as a record of progress. As a task is started and completed the open bar is filled in and the actual start and finish dates shown next to the scheduled start and completion times. (On future projects, this information can be used to gain a better estimate of how long it takes a team to complete various tasks.)

1.1.3.10 Lecture Topic 10: Economics and cost analyses - This topic addresses the importance of economics and limited resources in the design process. Economics imposes important constraints on design decisions, from developing a product that can compete economically with other products on the market, to developing a least-cost solution. Design teams are required to perform two cost analyses as part of their projects: the engineering costs and the cost of the product or project they design. An estimate of engineering costs is required in the *Proposal*. An estimate of the cost of producing the design (product manufacturing costs or construction costs) is required in the *Final Report*.

Engineering costs are discussed in the context of the team being a small consulting firm or a design team within a larger company. Manpower estimates are converted to costs by assuming reasonable salary rates for principals, senior/supervisory engineers, engineers and support personnel. Overhead/indirect costs are described as the many incidental costs a company must incur to do business, costs which cannot be directly assessed against any one specific project of the many projects a company may be doing. The concept of a "multiplier" for manpower costs to obtain an overhead rate is discussed along with how that "multiplier" may be obtained. The design teams are expected to use these concepts in their *Proposal* to estimate the cost of their being engaged to do the design. This lecture is one of the few times in the formal engineering curriculum where the "business of engineering" is discussed

NO.	TASK	JAN	FEB	MAR	APR	MAY	JUN.
1.	Identify design topic						
2.	Assemble design team						
3.	Identify alternatives						
4.	Submit topic form						
5.	Conduct research (literature review)						
6.	Establish personal contacts						
7.	Screen/evaluate alternatives						
8.	Obtain data						
9.	Analyze data						
10.	Develop preliminary design						
11.	Prepare draft proposal						
12.	Revise draft proposal						
13.	Submit proposal						
14.	Develop detailed design						
15.	Evaluate detailed design						
16.	Refine design						
17.	Prepare final design						
18.	Prepare presentation						
19.	Rehearse presentation						
20.	Make presentation						
21.	Prepare draft final report						
22.	Revise draft final report						
23.	Submit final report						

GANTT CHART - Freshman Design Project Schedule

Figure 1 A Typical Gantt Chart for Freshman Design Project

1.1.3.11 Lecture Topic 11: Environmental Impact - All designs have some impact on the environment; most impacts are predictable; however, some may be unforseeable. All designs consume some resources that could be otherwise used and these resources must be produced at some cost to the environment. Some projects may enhance the environment. Freshman design teams are made aware of these facts. Invariably, however, some teams protest that what they are designing has no environmental impact. Each team's *Proposal*, *Oral Presentation* and *Final Report* must address the environmental impact of their design. See Box 6.

BOX 6

ENVIRONMENTAL IMPACT

Each design report should address the environmental impact of the project. This can range from a detailed analysis of what the project or product will do to the environment - both positive and negative impacts - to a simple statement of what the designers believe the effect of their project will be on the environment. Obviously, some projects will have a significant impact on the environment while others may have minimal effect; however, no project has no impact. (It might be hard to predict the impact, but every project will consume some resources including materials and manpower and thus will have an environmental impact.)

1.1.3.12 Lecture Topic 12: Final Report and Graphical Communications - The contents of the final report are discussed in this lecture including the importance of graphical communications. The lecture content is coordinated with the humanities faculty to insure that design course and humanities course report requirements are consistent. Details of requirements for the final report are presented in Chapter 2, Section 2.6.0. Specifically, the final report contains: a cover and title page, a letter of transmittal, table of contents, problem definition, executive summary, introduction and background, solutions (past and present), previously completed work, alternative evaluated, constraints on the solution, statement of work/method of solution, summary and references. Each of these components is discussed.

In their final reports, students tend to use graphics obtained from references or from the internet but are often reluctant to produce their own graphics unless prodded to do so. The various types of graphics that might be included in a final report such as drawings, photographs, data graphs, etc. are discussed in this lecture along with their role in conveying information. See Box 7. Often figures and graphics provide the information base that initiates discussion in the text. Graphics provide the information while the text provides an interpretation of the graphics. Examples of various types of graphics are presented and students are encouraged to summarize their designs with appropriate maps, drawings, graphs and photographs.

BOX 7

GRAPHICS

Figures - drawings, photographs, data graphs

Tables - summaries of data, comparisons of data

Figures and tables convey a lot of information very succinctly. (There is truth in the saying that "a picture is worth 1000 words." Some ideas can best be conveyed by a picture and some can only be conveyed by a picture.)

Figures and tables can provide the basis for discussion in the text. Sometimes it is easier to produce the figures and tables first (as a result of your analysis) and then to produce the text that discusses each figure or table. The text should provide an "interpretation" of the graphic.

TYPES OF GRAPHICS

Maps - location of a project

Plans - site plans, building plans, architectural renderings.

Line Drawings - mechanical drawings of machinery, parts, circuit diagrams, etc.

Graphs - show data, the results of surveys, bar graphs, pie charts, "scatter" plots.

Photographs - what does it look like now?

Drawings/Sketches - what will it look like when you're done?

1.2 Expectations

1.2.1 Characteristics of Drexel Engineering Freshmen (1996-97). At Drexel, all freshman engineering students participate in the ED&L design program. Data on the characteristics of Drexel's freshman engineering class entering at the start of the 1996-97 academic year are given below. Of 493 entering engineering students, 94 were female and 399 were male; 448 students remained after the fall term and participated in the design course. Number of students by

engineering discipline is given in Table 1. SAT scores and TOEFL scores (for 12 students) are given in Table 2.

Table 1 Drexel's Engineering Freshman Class by Discipline (Winter Term, 1996-97 AY)

Discipline	Number	Percentage
Architectural Engineering	59	12.2%
Chemical Engineering	42	8.7%
Civil Engineering	27	5.6%
Electrical & Computer Engineering	114	23.6%
Mechanical Engineering & Mechanics	52	10.7%
Materials Engineering	7	1.4%
Undecided	147	30.4%

Table 2 SAT Scores, TOEFL Scores and High School GPA, Engineering Students Remaining, Winter Term 1996-97 Academic Year.

	Mean Score	Minimum Score	Maximum Score
SAT Math	621	430	800
SAT Verbal	560	280	780
SAT Total	**1182**	**740**	**1540**
High School GPA	3.3	2.1	4.0
TOEFL (12 students)	575	507	640

1.2.2 High school experience. About 5 or 6 weeks into their first term of the engineering curriculum, in ENG-AS100 *Introduction to University Life*, students were asked to write about their high school experience and what was different about college. By this time, students had experienced college life and had grades for several assignments and weekly examinations in CBFE I, PFE I and Mathematical Fundamentals of Engineering I (MFE I). Most wrote that high school had been easy and not very demanding of their time; good grades had been easy to obtain with minimal study time. However, most also recognized that that level of performance probably would not lead to satisfactory grades in college.

1.2.3 Expectations of Students in Design Many students are apprehensive about the design course because the thought of doing engineering design with their limited technical/engineering training and experience can be overwhelming. Consequently, they are encouraged to seek their advisor's help on a regular basis. Students are advised that the largest part of their project grade depends on what they learn about the process of design rather than the design itself; although, they will most likely also learn a lot of technical information. They are encouraged to "work hard" but to "explore" and "have fun" in the process. It is suggested that advisors base their grades about 50% on the students' learning about the design process and 50% on the quality of the design; however, negative outcomes are recognized as important and do not represent

"failure." A project that is found to not be technically or economically feasable is a legitimate outcome if the students have followed a sound design process.

Faculty who are inexperienced in working with freshmen must be informed of what they can and should expect. See Box 8. For example, a faculty advisor unaccustomed to working with freshmen expressed concern that his students were unable to solve the differential equations describing a building's motion during an earthquake! Generally, faculty are advised that students have limited experience and their formal analytical abilities are also limited. The design process rather than the design product is emphasized; however, the design report must include a technical component which applies something of what the students have learned in physics, chemistry, biology or mathematics to the design analysis.

BOX 8

NOTES FOR FRESHMAN DESIGN FACULTY

Expectations

Remember that most students participating in freshman design have had only one term of science and engineering courses. Expectations regarding the technical sophistication of their design projects should be tempered by this. The purpose of freshman design should be to show students what is involved in the iterative process of design: identifying a problem, carefully defining that problem, identifying constraints (technical, economic, social, etc.), postulating solutions, and evaluating and refining those solutions in view of the constraints to arrive at an optimum solution to the problem. See the attached definition of design. While we cannot expect technical sophistication, we can expect students to work hard, learn about and participate in the design process, to work together productively, to write well, to make technical presentations, to meet deadlines and, in the process, perhaps to learn something about the technical aspects of their design topic.

Remember also that a negative outcome - a project that is found to not be technically or economically feasible - does not represent failure. The expected or "hoped-for" outcome may not be valid and it is better to discover that early and not delude ourselves. The decision not to pursue a project further can be just as important as the decision to proceed. Also, what is important here is that students learn about the design process itself.

Requirements

Freshman design teams will generally be comprised of 4 or 5 students. Their design problem can be a topic of their own choosing or one suggested by a faculty member. They might initially "investigate" a design topic by discussing it with potential faculty advisors while they "home in" on a topic. It is their responsibility to "recruit" a faculty advisor who shares an interest in their topic. Advisors are chosen from a list of faculty who have agreed to serve in this capacity. They are usually engineering and science faculty but may also include faculty from other colleges with special expertise.

When a design team has selected a topic, they will prepare an problem definition statement and submit it to their advisor for approval/signature. If you agree and sign, you have obligated yourself to serve as advisor for that team. Students may also recruit co-advisors with special expertise if they wish; however, there is only one official advisor. ***The date for the submission of approved problem definition statements is XX January 199X at noon.***

Freshman design teams will prepare a proposal that will be submitted to you in draft form for comments. Hopefully, they will have met with you several times before the proposal is due and that the proposal will reflect your guidance. Based on your comments and those of their humanities instructor, they will revise the proposal and provide you with a final version. ***The date for submission of the final proposal is X March 199X at noon.***

During spring term, design teams will make a formal presentation of the results of their design analyses. ***The dates scheduled for design presentations are XX-XX April 199X***. As an advisor, you are expected to attend your team's presentation and to introduce them to the audience. Evaluation sheets will be distributed. Using your own evaluation and considering those of the audience, you will submit a grade for the presentation. The final design report will be due several weeks after the presentation. ***The date for submission of the final report is XX May 199X at noon.*** You will also be asked to submit a grade for the final report.

Suggestions

Meet with each of your design teams weekly for about 1/2 to 1 hour. Meetings early in the process should probably be about 1 hour; later in the process, shorter meetings usually suffice. Weekly meetings keep the students' attention focused on the course and precludes their postponing action until the last minute. They know that they will have to report some progress to their advisor and team members each week!

Also encourage them to have one or two additional 1-hour-long design team meetings each week and to keep records of what transpires at those meetings. Their meeting minutes should also document who will do what before the next meeting.

At your first meeting with them, help them define and "brainstorm" the problem. (Meeting with the whole team in a classroom or conference room with a blackboard helps.)
- Ask them to write the problem, as they see it, on the board,.
- Ask them to think about what they must know to solve the problem. This will force them to further define the problem.
- Ask them what constraints will be imposed on any possible solution: technical, economic, environmental, social, etc. Again, have them write the constraints on the board.

- Ask them to list the kind of data they might need to come up with a solution.
- Ask them what kind of expertise they need to solve the problem.

This exercise usually leads to several blackboards full of notes that, when reorganized, can serve as the basis for their proposal - and possibly as the outline for their final report.

At their weekly meetings with you, require that someone take minutes. Require an oral progress report from each team member on what they did in the preceding week. At the end of the meeting insure that each team member knows what he or she is to do before the next meeting. Encourage them to make contacts inside and outside of Drexel to obtain information and to discuss their design topic. The more ideas/opinions they consider, the better.

Suggest that they each *write* as they think about their design topic and as their work progresses. Clear writing leads to clear thinking and vice versa. Emphasize that writing as the design progresses will simplify the task of putting their final report together later. It becomes more a task of organizing and rewriting/editing than trying to produce a polished report at the last minute.

Other Sources of Information

Faculty should refer to the *Freshman Design* information on the *ED&L webpage* and to the *peer review* forms on the *Humanities webpage*.

1.3 Freshman Engingeering Design Faculty

1.3.1 Advisor Selection. Design team members are advised individually by their HUM107 & HUM108 instructor on writing the *Problem Definition Statement*, *Proposal, Oral Presentation and Final Report*. Teams are advised on the technical content of their work by a technical advisor selected by the team from the engineering and science faculty. Candidate engineering faculty advisors are identified by their respective department heads. The list of faculty identified as potential advisors is provided to the student design teams.

Faculty advisors are solicited from among the five engineering departments in the College of Engineering as well as from faculty in the College of Arts and Sciences who teach or have taught in the freshman engineering program. Each year engineering department heads are requested to name those members of their faculty who will participate in the freshman design program - usually from a list of faculty who have participated in the past. These faculty are informed of the details of how the program is conducted and are put on notice that they may be approached by one or more freshman design teams and asked to serve as their advisor. The number of teams advised by a faculty advisor varies. Other teaching, service, research commitments and faculty interest in the students' design topics all determine how many teams an advisor will take on.

Usually, the number of teams is limited to 3 or 4; however, some faculty have advised as many as 10 teams or co-advised up to 16 teams with other faculty. A number of faculty from the Physics & Atmospheric Sciences, Chemistry, Biology & Bioscience and Humanities & Communications Departments who have taught in the engineering program also serve as advisors. Since the students are exposed to these faculty in their other classes, the faculty are accessible, committed to educating freshman engineers and willing to work with design teams. Some faculty initially identified as potential advisors are not approached or selected by teams to serve as an advisor.

Not all faculty are suited to work with freshmen. Faculty who previously have not taught freshmen or freshman design are provided with guidance on how to interact with teams including what can reasonably be expected of the teams and suggestions on how to structure a team's operation. See Box 8.

Engineering and science faculty who serve as technical advisors are given relatively wide latitude on how they interact with their design teams. Different faculty have developed their own expectations and requirements of design teams. The faculty member's expectations and requirements are conveyed to the team as they talk/negotiate with a potential advisor. If the faculty member is selected as advisor, the requirements become a contract between the team and advisor. Since it is the advisor who ultimately determines the team's grade, the team members know that they must satisfy the advisor's requirements.

The following are guidelines established by Dr. Allen Rothwarf of Drexel's Department of Electrical and Computer Engineering for his design teams.

BOX 9
ADDITIONAL GUIDELINES FOR FRESHMAN DESIGN FACULTY

The following guidelines are those used by Dr. Allen Rothwarf, ECE. It is not mandatory that you operate with your freshman design teams in accordance with these guidelines; however, they represent a good set of procedures which you can adapt to your own mode of operation.

FRESHMAN DESIGN GUIDELINES
1. Each student on a design team should keep a bound notebook devoted solely to the project. In it the student is to put down everything done on the project - ideas, phone calls, minutes of meetings, research references, etc.

2. Students must meet weekly with their advisor.

3. Students must meet weekly amongst themselves.

4. Students must devote at least two hours per week to the project in addition to the meetings.

5. The student acting as group leader will rotate on a monthly basis among the students.

6. There must be a time line or schedule for the project, and it must be updated weekly, the group leader is responsible for doing this in consultation with the team members and the advisor.

7. In writing the abstract for the project, the problem being solved should be stressed, leaving as much flexibility as possible for finding a solution.

8. Early in the project the students should "brainstorm" amongst themselves and with their advisor as much as possible and research at least several promising approaches.

9. After picking the most promising approach to pursue, they should still keep one or two alternate approaches in mind, in the event that their most promising one fails early in their project.

10. Only about one in twenty ideas turns out to be practical under the best conditions; hence it is important to document and explain why an idea isn't practical, so that others won't waste time on it at some later time, or if the reason for its non-feasibility is later overcome due to technical developments, someone can continue the project to a successful conclusion.

1.4 Deliverables

1.4.1 The Problem Definition Statement The *Problem Definition Statement* is a brief paragraph (less than about 300 words) which draws on the team's initial research, through the library, internet and/or interviews to address each of the following:
- A one or two sentence definition of a problem the team intends to solve with an engineering design. What would the final design product look like in order to resolve the defined need (a product, product improvement, civil or architectural project, etc.)?
- How will the design satisfy that need?
- How is that need currently being satisfied and how will the new design change and improve things? (This provides an opportunity to justify the design.)
- Who will use or benefit from the design?
- What other ways might the need be met? What alternatives are there to the proposed design? (This provides an opportunity to assess competition in the marketplace for a product.)
- What problems will have to be surmounted in doing the design? (This will demonstrate that the team recognizes stumbling blocks, such as limitations on time, resources and expertise, they might encounter.)
- What constraints, technical, economic, environmental, social and political, must the design satisfy? Think of all the possible reasons the design might not be accepted.

- What constitutes a successful design? What criteria will be used to evaluate the design?

Freshmen often make exaggerated claims about what their proposed designs will accomplish. (This probably comes from watching too many TV commercials!) The advisor should discourage such wild, exaggerated claims and encourage objective, carefully thought out answers to the foregoing questions to produce *the Problem Definition Statement*.

The *Problem Definition Statement* is signed by the Faculty Advisor and Humanities Instructor and serves as approval to pursue the proposed design. The faculty advisor's signature serves as his/her commitment to serve as advisor for the team. A copy of the form is included in Appendix A.

1.4.2 The Proposal

The proposal is submitted at the beginning of the ninth week of the winter Quarter, usually in early march. The contents of the proposal are discussed with students in both HUM107 and ED&L lectures and teams have proposals peer reviewed in HUM107 recitations. See box 10 for contents of the proposal.

BOX 10

PROPOSAL HINTS

CONTENTS/OUTLINE - See HUM107 Syllabus for details of the Proposal's contents and outline. The hints below should help you by posing questions that should be answered in each section of the Proposal.

I. Cover/Title Page (See format on the ED&L web page.)

II. Problem Statement (a brief but complete statement of the problem you want to   solve and/or what you propose to accomplish by doing the design.)

III. Introduction/Background

> What are the results of your research into the problem? (Where did you look and
>   what did you find?)
> Other solutions, past and existing (What is currently being done to address the
> problem, if anything?)
> What work have others done?
> Cite your references. (See **VI References** below.)

A. Alternatives

What other ways of solving the problem did you consider?

Why did you reject some?

Why are others still under consideration?

Which one do you expect to be the most successful? Why?

B. Constraints

What do you have to watch out for?

What are you worried about?

Why might you not be successful?

Can you compete economically with other solutions? (Economic success)

What will you do to the environment?

Can you legally do what you want?

What are the social impacts?

Are there any safety considerations you need to be concerned about?

IV Statement of Work/Method of Solution

Specifically, what is it that you are going to do?

How are you going to do it?

What will the end result be?

V. Summary

Briefly restate the problem and how you will solve it.

VI. References

List your sources of information (journals, texts, articles in newspapers, magazines, personal contacts, Internet URLs, etc.) These references should be cited in the text of the Proposal.

VII. Qualifications

A. The Firm - Assume that your team comprises a small engineering firm or design team in a company and explain the history of the firm/design group and its experience.)

B. The Principals - Append the resume of each team member. (Use your co-op resume if you have one; if not, look at someone else's co-op resume and produce one for yourself in the same format - you'll have to do it eventually anyway!)

VIII. Budget for Engineering Services

What will it cost your client/company to obtain your team's services to do the design?

(Figure out how many people will be working on the project and how many hours each will contribute. Select an hourly rate for each team member. Remember to include "overhead," (the cost of providing an office, heat, light,

secretarial help and general administration - accounting, billing, entertaining potential clients, etc.) Overhead is usually included as a "multiplier" of salary costs associated with a project. Multipliers of 2 or 3 are not unusual for engineering firms.

IX. Schedule (Prepare a time line showing deadlines, tasks, and the duration of each task - Gantt Chart)

X. Appendixes (if needed to provide backup for the proposal) Appendixes are usually provided if you think someone may want to delve more deeply into some aspect of the proposal.

1.4.3 Design Conference - Oral Presentations A two-day design conference is held in late April at which design teams make an oral presentation on their design project. See Box 11. The conference is attended by the students' peers; engineering, science and humanities faculty, along with family and guests invited by the students. In the past, Drexel's admissions office has also invited high school students to attend selected presentations. Each team is afforded 1/2 hour in which to set up and make their presentation. The team's talk is limited to 15 or 20 minutes with 5 to 10 minutes for questions. Depending on the number of design teams, 3 or 4 concurrent sessions are held over the two days. A formal conference program is printed listing the time and location of each presentation along with the design project title, the names of team members and advisors. A copy of the Design Conference Program for 1997 is given in Appendix C.

An evaluation form is provided to anyone at the presentation who would like to fill one out. See Apendix A. Completed forms are provide to the team's technical advisor in order to provide other perspectives on the team's presentation and to assist in establishing the team's presentation grade. At least one instructor from the humanities program attends each design presentation; in some cases two or more humanities faculty attend. Humanities grades for the oral presentation are discussed among the humanities faculty at a meeting tempered by input from the audience evaluation forms.

BOX 11

FRESHMAN DESIGN PRESENTATION

Logistics

Date: XX-XX April 199X (no extensions, all presentations on these dates)

Duration: 1/2 hour per team
       5 minutes setup/changeover time
       15-20 minutes presentation (strictly   enforced)
       5-10 minutes for questions

<u>Who:</u>

All team members must participate in the presentation.

<u>Projection requirements:</u>

Please include any special projection requirements on your presentation registration form.

<u>Visitors:</u>

- You may invite parents, relatives, friends, etc.

- There may be visitors from area high schools.

- Presentations may be videotaped.

Hints:

- Prepare adequately for your presentation.
- Prepare "graphics" that illustrate what you have designed ("before": and "after"?)
- Describe the technical details using graphics if possible ("A picture is worth a thousand words!")
- Practice your presentation as a team and constructively criticize one another's presentations.
- "Dry-run" your presentation for your advisor. (Do this the week before so that you will have time to make any revisions before "D-day.")
- Have "backup" plan for the event that your fancy, high-tech presentation software crashes, e.g. have transparencies too.
- Dress appropriately.
- Presentations should be made in a "business-like" manner. (Imagine that you are making presentation to your client/boss and that your next project/raise depends on how well you do.)
- Introduce yourself, title of project, "team" and team members.

Suggested Outline:

- Introductions, Title of Project, etc.
- Overview of Talk (give an outline of what you are going to present.
- Problem Background
- Problem Statement
- Work done toward solution of problem.
- Solution (details of your solution to the design problem)

• Technical details (What are the technical details of your solution.)
• Costs (What will it cost to build, manufacture, implement?)
• Environmental and other impacts (If your design is executed, what will the impact   be on the environment, on society, on how people live their lives?)
• Summary/Recommendations for future work.

SIMPLIFIED OUTLINE

"Tell 'em what you're gonna tell 'em!

Tell 'em!

Tell 'em what you told 'em!"

1.4.4 Final Report

The final report is due about three weeks after the oral presentation, usually the beginning of the third week of May. The final report is discussed in ED&L lecture. See Box 12. However, the final report is a major element of HUM108 and students receive most assistance in that course. See Chapter 2, Section 2.5.

BOX 12

ENGR 131 ENGINEERING DESIGN AND LABORATORY

FINAL REPORT GUIDELINES

A FINAL REPORT

1. PRINT ON 8⅞x 11" PAPER, one side of the sheet only; place in a binder with a clear cover showing the title page.

2. THE REPORT should not exceed 10 pages of text, excluding figures and appendixes. (Note that the Abstract and Executive Summary are separate pages and do not count in the 10 page limit.)

3. SUBMIT COPIES OF THE FINAL REPORT by Friday, xx May 199x as follows:

1 copy to team's technical advisor and 1 copy to each team member's humanities instructor. (If several team members share the same humanities instructor,   that instructor need get only one copy from the team.)

4. CONTENT:

A. LETTER OF TRANSMITTAL - letter to technical advisor transmitting the report.

B. TITLE PAGE - must follow the format of the "Final Report Title Page" on the ED&L web page.

C. ABSTRACT - no more than 150 words (one page limit) on a separate page of the report.

D. EXECUTIVE SUMMARY - a separate, one page document whose audience is a non-technical executive with decision-making responsibility.

E. TABLE OF CONTENTS - list all sections of the report, the appendixes, figures, tables, etc. with page numbers.

F. INTRODUCTION - should include:
1. Problem Background
2. Survey of the Literature
3. Problem Statement/Objectives
4. Constraints on the Solution
5. Criteria Used to Obtain/Optimize the Solution

G. THE SOLUTION - should address:
1. Statement of Work (Alternatives Considered)
2. Results - The Solution

H. DISCUSSION AND CONCLUSIONS - errors, validity, assumptions, costs, benefits, etc.

I. RECOMMENDATIONS FOR FUTURE WORK - a guide to others who might continue the project.

J. REFERENCES - list in order of appearance in you document, with citation numbers, e.g. [5]; refer to the *Handbook of Technical Writing*;

K. ACKNOWLEDGEMENTS - of assistance, support, etc.

L. APPENDIXES - only if needed to fully document report background, calculations, computer program listings, etc.

NOTE: Stress must be placed upon proper drawings and pictoral sketches to fully explain and communicate the final results of the project.

1.5 Assessment/Grading

A team's ED&L grade is assigned by the technical advisor based on the team's overall performance. The quality of the four deliverables, the *Problem Definition Statement*, *Proposal*, *Oral Presentation* and *Final Report* form the tangible basis for the grade; however,

other factors may enter into the grade such as participation of individual team members. In the 1996-97 academic year, advisors were asked to submit a single grade for the team only after the design component of ED&L was completed, i.e., after the *Final Report* was submitted in May. The grade was to be a composite of the grades for each of the 4 deliverables. Recommended weights for deliverables were:

Problem Definition Statement	10%
Proposal	20%
Oral Presentation	30%
Final Report	40%

Earlier attempts to solicit grades for each deliverable after it was completed were unsuccessful. However, the submission of a single grade appears to have led to "grade inflation." In the 1996-97 academic year there were 99 four- or five-member design teams involving 429 students. Of the 429 students, 261 received As, 103 received Bs, 14 received Cs and 7 received Ds. None of the students failed although 44 dropped the course; most because they transferred to another curriculum. The grade inflation attests somewhat to the advisors' pride in and attachment to their teams and to their desire to see the team be successful. In some cases it may be due to an advisor's failure to understand expectations. To counter the grade inflation, a new assessment/grading system will be introduced in the 1997-98 academic year. Assessment forms outlining what students are expected to learn at each stage of the design process and in the preparation of each deliverable have been developed with the help of a consultant, Dr. Jack McGourty, of Assessment Alternatives, Inc. Copies of the assessment forms are given in Appendix B. Similar forms have been developed for the humanities component of the program. The forms are "a work in progress" and will be revised as experience with them is gained.

1.6 Summary/Conclusion

The design portion of ED&L represents 4-quarter credits distributed over two quarters. Student teams prepare a *Problem Definition Statement*, a *Proposal*, and *Final Report* and make an *Oral Presentation* of their project. The design team's ED&L grade is based in part on each of these deliverables. In addition, the quality of these products is a portion of their individual grades in HUM107 and HUM108, the second and third humanities courses required of engineering fresmen.

The freshman design program at Drexel afford students an opportunity to experience working on a design team under the technical guidance of engineering and/or science faculty and with guidance on written and oral communications by the humanities faculty. A major strength of the program is the close linkage of the humanities faculty with the design faculty. What is taught in the ED&L (design) portion of the course is reinforced in the Humanities portion and vice versa. Thus students learn from both engineering and humanities faculty the importance of effective communication for engineers. The design project serves as a vehicle to impress this on students. Humanities faculty stress the importance of critical thinking. Appreciation for literature and the

arts is also an important part of humanities portion of the program and serves to dispel the image of a purely technical engineer.

Close interaction of teams with faculty is believed to be an important element of the design program. In many cases, a mentor-student relationship develops. Students get to know engineering faculty and "experience" engineering early in their college careers.

Emphasis is more on learning about the process of design rather than on the design itself, although the technical content of the project does not play an insignificant role. Students learn to carefully define the problem they seek to solve. This may lead them to a solution other than the one they thought would constitute their design. They identify constraints imposed on their design: technical, economic, safety, environmental, legal, social and political. They identify alternative solutions and alternative designs and they use analytical methods to evaluate those alternatives. Because they are at the beginning of their engineering careers, a high level of analytical sophistication is not expected; however, common sense, team work, collaboration, in-depth research and hard work are expected.

The program continues to evolve. There is always room for improvement. This year, practicing engineers will be invited to work with freshman design teams and their advisors. Teams will meet with practicing engineers in their offices to experience an engineering workplace. Also, additional lectures are being developed. For example, how to use a decision matrix to evaluate alternative solutions will be included this year. The matrix system developed in the Dartmouth Project for Teaching Engineering Problem Solving will be used (Frye, 19xx). Team dynamics and how to handle operational problems associated with dysfunctional teams remains a topic to be included; it is presently only touched upon. But then, team problems are also a reality in the work place and the course is intended to provide aspiring engineers with a "dose of reality."

CHAPTER 2

HUMANITIES IN THE DESIGN COURSE

Marijo Makufka

2.0 Introduction

Many have looked at the design process, or at invention and innovation, or at the diffusion of technology, and sought to explain how and why technology takes the form we see and experience. Often forgotten is the necessary element of communicating new ideas: to give to others that which has been realized. In the engineering program at Drexel University, the student's ability to define, describe, and develop technological design is often the bulk of the process and end result. In the three written deliverables of the freshman design project, The *Problem Definition Statement*, *Proposal and Final Report*, the Humanities Sequence develops the necessary elements of effective communication, an understanding of audience, and creativity in problem solving. In doing so, design moves beyond the personally tested and understood to the wider realm of knowledge for external consumption.

2.1 Humanities Sequence in Design

Drexel University's "internationally emulated" design course won the "first Accreditation Board for Engineering and Technology award for Excellence in Curriculum Innovation and several of its program emphases are now incorporated in ABET's 'Engineering Criteria 2000'" (Arms, 1997). The Humanities Sequence of the design course emphasizes the following:

- an understanding of professional and ethical responsibility
- an ability to communicate effectively
- the broad education necessary to understand the impact of engineering solutions in a global/societal context
- a recognition of the need for and an ability to engage in life-long learning
- a knowledge of contemporary issues

2.1.1 Effective Communication In design, scientific principle and form are indeed important--including physics, chemistry and biology--but often times language and conveying discoveries becomes the determinant of technology's function and form. Humanities instructors in the engineering curriculum state, "if you are unable to clearly express your ideas, the larger world will not know of them."

For engineers, the ability to write and speak clearly is most essential, for however good they may be as analysts or experimenters, if they cannot convey their ideas clearly, concisely, and interestingly to others, then they are like strangers in a foreign country whose people cannot understand them. The transmittal of information includes writing, drawing and speaking.

There may have been a time when engineers were not required to write reports, when they could let their ideas be known by word of mouth or by circulating an occasional sketch or drawing, but these times are gone. Today engineers cannot be "heard" unless their ideas are written down in proposals and their findings are recorded in reports. This does not mean that the spoken word and the drawing or sketch have lost their importance, but rather that they must be supplemented by the written word. Therefore, it is important for engineers to know how best to communicate ideas to a reader; how to put their best foot forward with a client whom they may never see, or with the company vice-president to whom they will report.

Although technical writing is often directed toward others with similar backgrounds, more and more engineers are required to write for an audience unfamiliar with technical terms. They must be able to express thoughts in terminology that can be understood by intelligent persons outside of the engineering field. During the years to come, the need for cooperation between technical and non-technical persons becomes increasingly important. Engineers must learn to communicate with people of all types of backgrounds, and they must be able to state their views clearly and concisely.

2.1.2 Audience Understanding audience is vital in the design process. Successful design relies upon a full understanding of material culture; the social, political, and economic context of modern life; the actions, interests, and needs of corporate managers, consumers, stockholders, and workers; and so on. Students who respond to the needs of their consumers (be it individual buyers or corporations) successfully design and develop wares which are competitive. Products that meet the consumerís needs, at an affordable cost, are designs that thrive. Students who design without this knowledge find themselves floating free in the crowded maze of the marketplace.

To reach the widest audience, engineers should consider the following (Michaelson, 1982):

- Make a plan--after defining the objectives of the work, assess potential readers and select at the start a suitable vehicle for the manuscript.
- Orient the reader--state the engineering problem or purpose early in the manuscript, and show how it relates to previous work and to current problems.
- Emphasize the strong points--show the ingenuity of the contribution being made.
- Choose the proper amount of detail--too little detail is disappointing and frustrating; too much detail is boring and confusing.
- Show the overall significance--explain how the paper fills an existing need, how it clarifies a current problem, how it offers a useful application and why it is important.
- Get peer reviews--be certain to show the draft to technical experts; they serve as test samples of reader reaction.

2.1.3 Creativity in Problem Solving Design is a creative and stimulating activity, often as much akin to art and architecture as to science. Engineers in today's environment must be both

versatile and sensitive. Einstein said, "Imagination is more important than knowledge." Creativity is a human endeavor which presupposes an understanding of human experience and human values, and is without doubt one of the highest forms of mental activity. Creative thought may be expressed in such diverse areas as a suspension bridge, a musical composition, a poem, a painting, or a new type of engineering process.

Imaginative thinking can be stimulated and the basic principles of innovative thinking can be mastered. In the study entitled "Development of Individual Creative Talent," Arnold Osborn notes that "for an experimental sample of 330 students, the subjects who enrolled in courses in creative problem solving produced 94 percent more good ideas than subjects who did not get such training," (Osborn, 1995, pp 54). This indicates that creative thinking and problem solving can be taught and, therefore, that all young engineering students can profit from studying the principles used to spark innovation and creative effort.

2.2 The Problem Statement, Proposal and Final Report

Students in Drexel University's freshman design program must complete three written deliverables: the problem statement, proposal, and final report. The Humanities Sequence aids in the development of these tangible products by fully becoming part of the process. Following will be descriptions of the assignments and suggestions on presenting the material. Since Drexel University's policy is to make lecture time as interactive as possible, many of the following materials are geared toward student response.

2.3 The Problem Statement

Engineers who master the fundamental principles of mathematics and science are able to understand the laws of nature. If this were the total requirement, the task of engineers would be simplified. However, engineers never operate in a free environment where they are limited only by the laws of nature. They must always endeavor to bridge between the "desires of people" and the "realities of nature." Because of these practical considerations, they are limited by artificial or human-made restrictions, such as time, money, or personal preference. These restrictions necessitate compromises on the part of the engineer. Presenting the concept of the problem statement that takes into account these areas of the nature of the real world enables engineers to produce novel solutions that are both desirable and economically justified as well as socially and ethically sound.

2.3.1 Defining the Problem Statement The problem statement is initially described in Chapter 1, Section 1.1.3.3 and 1.4.1. In the assignment, students are to define:

- the problem the team hopes to solve;
- solutions that currently exist (if any);
- how the proposed design will improve the present situation;

- constraints on the solution (including technical, economic, social, political, environmental, etc.)

2.3.2 Conceptual Block At Stanford, a term called "conceptual block" was penned and means "mental walls which block the problem-solver from correctly perceiving a problem or conceiving its solution," (Adams, 1974, pp 10-11).

2.3.2.1 Cultural Blocks: The following are examples of Cultural Blocks (Adams, 1974, pp 31):

- Fantasy and reflection are a waste of time, lazy, even crazy
- Playfulness is for children only
- Problem-solving is a serious business and humor is out of place
- Reason, logic, numbers, utility, practicality are *good*; feeling, intuition, qualitative judgments, pleasure are *bad*;
- Tradition is preferable to change
- Any problem can be solved by scientific thinking and a lot of money
- Taboos

2.3.2.2 Environmental Blocks: The following are examples of Environmental Blocks (Adams, 1974, pp 31):

- Lack of cooperation and trust among colleagues
- Autocratic bosses who values only their own ideas; do not reward
- others
- Distractions--phone, easy intrusions
- Lack of support to bring ideas into action
-

2.3.3 Problem Identification Proper problem-identification is of extreme importance in problem-solving. To successfully diagnose a medical ailment is to isolate the problem. This is true of any problem-solving. By working as an engineer, and therefore as a professional problem solver, it is vital to remain continually alert in order to properly perceive the problem.

Student Exercise: A team of four freshman engineers worked on devising a solar-powered bicycle for elderly or disabled riders who are still able to pedal and maneuver a bicycle, but who may become overly tired and need the aid of a motor to return home. The students identified the need for an engine able to power the weight of the solar panels, the bike frame, and the hardware needed to connect the mechanics to the bicycle, but did not identify the power needed to carry the rider, a potential added weight of 120
 to 200 pounds. This realization came only after the eighth week of their work. What other issues may they have overlooked in identifying the problem?

2.3.4   Alternate Solutions   Engineers occasionally become so involved in attempting to optimize a particular device that they lose sight of alternate ways to alleviate the difficulty. By doing so, they lose sight of many potentially superior designs.

Student Exercise: Much thinking went into the mechanical design of various types of prototype tomato pickers before someone realized that the real problem was not coming up with the best design of a picker but rather in the bruising of tomatoes during picking. The answer developed was a new plant with tougher-skinned, more accessible fruit. List other hasty solutions that have been made in engineering designs in the last ten years and potential alternate solutions.

2.3.5   Problem Isolation   Difficulty in isolating the problem is often due to the tendency to spend a minimum of effort on problem-definition to get to the important matter of solving it.

Student Exercise: Four freshman engineering students worked on designing an underground mail shuttle system for the elderly whose mailboxes were at the end of a long driveway. They identified the need for the product since many elderly people must hire someone to bring the mail to them or have family members become responsible for bringing the mail. In their rush to solve the problem, the student engineers did not isolate such problems as retrieving the underground mail if a mechanical failure occurred or problems with interference with power or water lines. What other potential problems should they have isolated?

2.3.6   Constraints   Often engineers fall prey to conceptual blocks due to reliance on restricted experience in problem solving. Strange as it may seem, often the more original and novel an idea is, the more vulnerable it is to criticism. Often the people most apt to prejudge a situation and allow past experiences to strangle a new idea are the ones whose analytical abilities have carried them to prior success.

Constraints resulting from experience and perception are (Adams, 1974, pp 35):

- Limited scope of basic knowledge
- Failure to recognize all the conditions relating to the problem--failure to get all the facts
- Preconception and reliance upon the history of other events
- Failure to investigate both the obvious and the trivial
- Artificial restriction of the problem
- Failure to recognize the real problem
- Inclusion of extraneous environmental factors
- Failure to distinguish between cause and effect
- Inability to manipulate the abstract

Student Exercise: Draw four straight lines without lifting the pencil from the paper which will cross through all nine dots (see Figures 2-1, 2-2 and 2-3 at end of chapter).

2.3.7 Limited Definition   In general, the more broadly a problem can be stated, the more room there is available for conceptualization. A problem statement which is too limited inhibits creative ability.

Student Exercise: If you are a resident at the university, imagine a very specific problem with dormitory life. If you are a commuter, imagine a very specific problem with traveling to and from campus. Write a solution to the problem that you are certain will work. After careful time and consideration, write at least three other solutions without worrying whether or not they will work.

2.3.8 Various Viewpoints   It is often difficult to see a problem from the viewpoint of all interests and parties involved. However, consideration of such viewpoints not only leads to a "better" solution to the problem in that it pleases more interests and individuals, but it is extremely helpful in conceptualizing.

Student Exercise: Pick an interpersonal problem you are currently having. Write a concise statement of it. Write of the same problem as seen by each party involved.

2.3.9 Vertical Thinking vs. Lateral Thinking Vertical Thinking begins with a single concept and then proceeds with that concept until a solution is reached. Lateral Thinking refers to thinking that generates alternative ways of seeing a problem before seeking a solution (Adams, 1974, pp 23).

Student Exercise: Logic is the tool that is used to dig holes deeper and bigger, to make them altogether better holes. But if the hole is in the wrong place, then no amount of improvement is going to put it in the right place. No matter how obvious this may seem to every digger, it is still easier to go on digging in the same place than to start all over again in a new place. Vertical thinking is digging the same hole deeper; lateral thinking is trying again elsewhere. Write which type of thinking you feel is better. If it is situational, explain which type of thinking is best for which tasks.

2.3.10 Bug List In order to think of a potentially successful design, it is necessary to establish a specific need.

- Interview People: For instance, you could go to the nearest hospital and start asking people on the staff what they need.
- Consumer Group: Imagine you are a truck driver and see if you can think of something that you would need.
- Yourself as the Consumer: You must have needs which other people in the world share, and if you could identify such needs, you could invent something to satisfy them.

A problem which most people cope with is a tendency to set up too enormous of a task. If one of your needs is to eliminate air pollution or eliminate violence, you are setting yourself a tall task. It is better to find a way to eliminate your neighbor's dog droppings from your lawn.

Student Exercise: Write a list of specific, small-scale needs. Remember humor. If you run out of bugs before 5 minutes, you may be suffering from the aforementioned blocks.

An example of Stanford Engineering Student's Bug List is shown in Table 2-1. They are not as narrowly defined as some students may like. For example, soft ice cream could mean the students disliked how quickly soft ice cream melts, that there is a problem with the mechanism that distributes soft ice cream, and so on. That the list is open-ended is important in finding new problems and solutions.

Table 2-1

Bug List of Stanford Engineering Students

- TV dinners
- plastic flowers
- buying a car
- instant breakfast
- relatives
- sewing buttons
- paperless toilets
- hangnails
- men's fashions
- small, yapping dogs
- rotten oranges
- soft ice cream
- cleaning the oven
- crooked cue sticks
- no urinals in home
- static electricity shocks
- broken shoe-laces
- polishing shoes
- bumper sticker removal
- pictures that don't hang straight
- cloudy ice cubes
- newspaper ink smears
- swing-out garage doors
- doors that swell in damp weather
- damp weather

2.3.11 Ways to Break Conceptual Blocks   The following list explains a method which breaks Conceptual Blocks (Adams, 1974, pp 93):

- Question what Currently Exists
- Understand the Problem
- Use Visual Thinking
- Use other Sensory Languages
- Brainstorm

2.4.0 The Proposal   The proposal tries to sell an idea, tries to convince a client or a superior to make funds available for the preliminary design. The proposal is written for one person or organization and is an attempt to sell an idea. Therefore, what is good advice for people in sales is also good advice for the proposal writer: engineers should put themselves in the position of the client, find out what the client's needs and wants are, and see to what extent their ideas meet these standards. Engineers should find out who else competes for the funds that might be used to further the same idea and emphasize those special points that make their idea or talents superior to that of the competition.

2.4.1 Defining the Proposal   The proposal is initially described in Chapter 1, Section 1.4.2. In the assignment, students should deliver the:

- Problem Statement
- Introduction and Background
- Solutions (past and existing)
- Previously Completed Work
- Alternative solutions
- Constraints on the solution (including technical, economic, social, political, environmental, etc.)
- Statement of Work/Method of Solution
- Summary
- References
- Qualifications of Engineering Team
- Budget for Engineering Services
- Schedule for Work

2.4.2 Proposal Description   The engineering proposal may be defined as a document designed to sell a potential customer on the ability of a company to supply a product or to perform a service of a technical nature. The customer may be an individual, another company, or a government agency. Essentially, the proposal tells what the company seeking work will do, how it will do it, and the terms under which it will act (Clarke, 1978, pp 7).

Legally, the proposal is an offer to perform a task, usually in response to an inquiry. As a preliminary step toward the negotiation of a formal contract, it specifies costs and the conditions

of performance, and it supplies a technical description of how the task will be accomplished. The terms of the proposal may become part of a bidding contract upon acceptance, or they may be used only as a basis for further negotiation (Clarke, 1978, pp 7).

2.4.3 Types of Proposals There are two types of engineering proposals. The first is the *solicited* proposal which is in response to a formal invitation, and the second is the *unsolicited* proposal, in which the supplier himself perceives the customer's need and proposes to fill it (Clarke, 1978, pp 9).

2.4.4 Four Elements of Proposals The engineering proposal is built upon four key elements. These are (Clarke, 1978, pp 10):

- what the engineer proposes to do (the activity);
- how the engineer proposes to do it (technical approach);
- how the engineer plans to do it (the procedure);
- what the engineer proposes to do with it (facilities and capabilities)

These four elements convey the entire proposal message.

2.4.5 The Importance of Quality in the Proposal Essentially, the engineering proposal is a sales package that must *by itself* sell the ability of the company that submits it. It is the complete package--the total message. Like the salesperson, it represents the company, and if it is successful, it can bring in valuable business.

Obviously, this package should be of high quality. No company would knowingly send out a sales representative who used bad grammar, who told an incoherent story, or was unkempt. Yet many otherwise highly qualified companies have submitted proposals with equally bad characteristics (Clarke, 1978, pp 12).

2.4.6 Content of the Proposal In content, proposals should have:

- Logical organization
- Clear writing
- Effective use of graphics
- Thoroughness
- Absence of errors

2.4.7 The Proposal as a Document As a document, proposals should have:

- Legible type
- Clear reproduction
- Absence of typographical or grammatical errors
- Neat covers and bindings

2.4.8 Elements of the Proposal

2.4.8.1 Introductory Material Introductory material for the solicited proposal has three functions: first, it summarizes general information as to the origin and scope of the proposal; second, it offers general comments on the requirements of the invitation and the intent of the submitter, and third, it serves as a "lead-in" for technical or other descriptions. For the unsolicited proposal, there is a fourth requisite: valid reasons must be offered for doing the work proposed (Clarke, 1978, pp 47).

Certain comments and precautions apply to introductory material. These are listed and analyzed as (Clarke, 1978, pp 46):

- <u>Length</u>. Introductory material should be brief. Its length may require from one to five pages, depending upon the type of proposal. As a rule, the unsolicited proposal requires a more extensive introduction. In the solicited proposal, the problems and goals are clearly stated in the invitation, and the value of the work is obviously well known to the potential customer. In the unsolicited proposal, however, these factors must be stated, and the value of the work, especially, must be convincingly set forth.
- <u>Discussion</u>. Avoid the discussion section at the beginning of the proposal. Clarity is often lost in this area.
- <u>Redundancy.</u> When writing introductions, there is a danger of paraphrasing or even quoting other parts of the proposal. The result of this is to seriously dilute the effectiveness of the proposal.

2.4.8.2 Method of Solution The heart of the proposal is the Method of Solution. All other information in the proposal serves only to support and supplement this section. The organization of the Method of Solution, and its technical content, directly mirrors the competence and capabilities of the engineering staff and its management. It provides a clear picture of the knowledge of the staff, and its awareness of the latest advances in technology. More than any other part, this section will determine whether or not the proposal is viable (Clarke, 1978, pp 55).

It should be noted that not all of the following described parts of the Method of Solution must be used in the freshman design project. Instructors can choose which topics they think are of value in initial design requirements.

2.4.8.3 Summary of the Method of Solution Every good piece of expository writing begins with a brief summary of the content. This section alerts the reader of what is to follow (Clarke, 1978, pp 56).

2.4.8.4 Planning: Phases and Tasks In scheduling and planning an engineering effort, the major and minor activities may be identified as phases and tasks. A phase is defined as a major activity that culminates in a firm conclusion or result; for example, a typical three-phase program might be (1) Feasibility Study, (2) Prototype Fabrication and Laboratory Testing, and (3) Field Testing.

Typical phases and/or tasks are listed as sub-topics as follows (Clarke, 1978, pp 58):

- Planning
- Study
- Personnel assignment
- Initial design
- Design drawings
- Purchase components
- Design evaluation
- Feasibility analysis

There are many more phases, but the above list serves as an example.

2.4.8.5 Comments on Requirements This is a detailed discussion and analysis of the requirements of the potential customer. This section should not be an aimless dissertation, but should show clearly the thinking that led to the proposed design (Clarke, 1978, pp 59).

2.4.8.6 Analysis of Major Problems This topic covers identification and analysis of the major problems that must be resolved if the objectives are to be achieved. The problems identified have bearing both on the technical approach and the scheduling (Clarke, 1978, pp 59).

2.4.8.7 Design Study The goal of such a study is the establishment of a firm design. Usually, it involves study of similar and related equipment, systems, or products (Clarke, 1978, pp 59).

2.4.8.8 Plan of Attack Where major premises are offered, as in a research program, this is a procedure that is thought will lead to the desired objectives (Clarke, 1978, pp 59).

2.4.8.9 Alternate Approaches This is a brief description of alternate approaches that were considered in evolving the final design. Reasons for rejection should be given (Clarke, 1978, pp 60).

2.4.8.10 Literature Survey A survey of the literature is required. Survey topics include the following (Clarke, 1978, pp 60):

- Description of program
- Facilities available within organization

- Facilities available outside of organization
- Information retrieval
- Method of analysis
- Plan of procedure
- Purpose and objectives
- Organization
- Scope of survey

2.4.8.11 Technical Survey This is similar to the literature survey except that techniques, methods, procedures, equipment, or systems may have to be examined, rather than a body of knowledge. Access to such special information and equipment may be required for the success of the solution, and the need for access may have to be specified and justified in the proposal (Clarke, 1978, pp 60).

2.4.8.12 Background History and Analysis This topic covers substantiating historical information; especially important research programs. The information presented should support the method of solution and the feasibility statement (Clarke, 1978, pp 60).

2.4.8.13 Statement of Work Used primarily in unsolicited proposals, or in solicited proposals where the requirements are not exact, this is a detailed description as to exactly what is to be accomplished (Clarke, 1978, pp 60).

2.4.8.14 Prediction as to Success of Method of Solution All methods do not attain their objectives, so a fair appraisal of the chances of meeting the objectives should be provided. Also, it should be specified just what objectives can be met fully, and those that will be met only partially (Clarke, 1978, pp 62).

2.4.8.15 Description of Operation If the equipment or system is complex, a detailed description of its operation may be necessary. However, details should be given only in sufficient depth for comprehension (Clarke, 1978, pp 62).

2.4.8.16 Prototype Development Self-explanatory.

2.4.8.17 Evaluation of the Method of Solution This is an impartial evaluation of the work proposed in terms of time- and material-savings, cost-saving, and contribution to technology (Clarke, 1978, pp 71).

2.4.8.18 Summary of the Method of Solution This is a summing up of the technical method of solution done briefly and to the point (Clarke, 1978, pp 72).

2.4.9 Qualities of a Proposal Writer The proposal writer is the key member of the proposal team. While someone else may initiate the proposal, and others evolve the technical approach, it is the proposal writer who sees to it that the job gets done. The writer guides the

contributors, shapes the proposal for maximum responsiveness, ensures its quality, writes essential parts, steers it through production, and finally, sees it mailed in time for the deadline. Most important, the writer creates an environment of "general activity and capability" that frees the contributing engineers and scientists to create the best possible technical approach. An individual of such vital activities must have outstanding qualifications (Clarke, 1978, pp 153).

2.4.9.1 Technical Knowledge The proposal writer must have as much technical know-how as possible. The writer must be able to grasp information quickly and be able to speak the language of the engineer and scientist. Most important, the writer must be familiar with sources of technical information (Clarke, 1978, pp 154).

2.4.9.2 Writing Skill The proposal writer must be able to produce clear, uncomplicated prose and must be able to write rapidly and fluently under deadline pressure. The writer must know how to punctuate and spell with accuracy (Clarke, 1978, pp 154).

2.4.9.3 Skill in Use of Graphics Illustrations are an integral part of the proposal, so the writer must be able to think in terms of graphics as well as words. The writer must be able to (Clarke, 1978, pp 156):

- Originate graphics and select the best medium;
- Evaluate quality and recommend improvements;
- Know the mechanics of sizing, retouching and presenting

2.4.9.4 Planning and Organizing Ability Creating a proposal requires a high order of ability to plan and organize not only words, but the efforts of individuals as well (Clarke, 1978, pp 157).

2.4.9.5 Thoroughness By nature and training, the proposal writer must be able to tie up all loose ends of the proposal. Numbers must be checked, pagination verified, all errors combed out--all to the end of creating a flawless proposal (Clarke, 1978, pp 157).

2.4.9.6 Diplomacy Unlike those in other fields of writing, the proposal writer cannot work alone. The necessary abilities include being (Clarke, 1978, pp 157):

- an effective team leader;
- a reporter, able to comb the other team members and find facilities and capabilities;
- a conduit to the contributing engineer

In these activities, and in producing proposals, writers will find many sources of resistance. Against these sources, the most effective weapon is diplomacy.

2.4.9.7 Inventiveness The proposal writer must devise new and better ways of making better proposals and more effective ways of selling the company's capabilities.

2.5.0 The Final Report Once the engineer has made the model, completed the necessary analysis, tested assumptions and performance, and related the design to the environment in which it must operate, it is time to report on these activities. Reporting is the process of information transfer. "Formal reports are the written communications sent to a client or other organization. They are often written to fulfill some contractual arrangement or are part of the contract itself. Formal reports are frequently the outcome of months or years of data collections," (Lee, 1990, pp 244). Final reports include concise but inclusive descriptions of the research objectives, methodology and findings.

Much of the report has been written as the proposal. Whole sections of the proposal can often be used just as they are written with the exception of changing from the future tense of the proposal to the past tense of the report. Areas that were already discussed in the proposal section of this report will not be covered in detail here.

2.5.1 Presenting the Final Report The organization of the final report is presented in the *Manual for Humanities* prepared by Drexel University's Humanities Team (pp 50-58). In the final report students should deliver the following:

- Cover and Title Page
- Letter of Transmittal
- Table of Contents
- Problem Definition
- Executive Summary
- Introduction and Background
- Solutions (past and existing)
- Previously Completed Work
- Alternative solutions
- Constraints on the solution (including technical, economic, social, political, environmental, etc.)
- Statement of Work/Method of Solution
- Summary
- References

2.5.2 Organizing the Final Report In organizing the information for the final report, the following should be considered (Michaelson, 1982, pp 23):

- What are the key ideas for the paper?
- Which are the supporting ideas to be subordinated?
- What details need to be included?
- What is the emphasis: the data, the method, your recommendations, a new applications, a unique design, etc.?
- How long should the manuscript be?

- What should be chosen for the main illustrations and tables of data?
- What information should be relegated to an appendix?

Most engineers use outlines of one kind or another which shows the intended structure and emphasis and clears the way for the writing project.

2.5.2.1 Title Page The title page should include the title of the report (clear and succinct), the researchers' names, date and the organization to which the report is submitted.

2.5.2.2 Letter of Transmittal The letter of transmittal is written to the organization requesting the information, is usually written in conversational language, and addresses the main idea of the report. Included could be a brief indication of the outcome, conclusions and recommendations, and a brief synopsis of the background, methodology and limitations (*Manual*, pp 51).

2.5.2.3 Table of Contents The table of contents usually lists the major topics, sub-topics, tables, figures, and appendices. The adoption of strong, descriptive headings, i.e., the short titles that define sections and subsections, is important because they break up the manuscript into manageable portions, easily seen and identified. Well chosen headings are not only an aid to the reader but also a reminder to the author to keep in focus the content of each section.

2.5.2.4 Problem Description See Chapter 1, Section 1.1.3.3 of this report.

2.5.2.5 Executive Summary The executive summary is, in many ways, the most important part of the final report and is written directly for the executive. It should be approximately one-tenth the length of the entire report, and should include the purpose, scope, methods, data sources, facts and figures, statement of results, conclusions and recommendations (*Manual*, pp 52).

2.5.2.6 Introduction and Background For most authors the introduction is the most difficult and troublesome section to prepare. Even after methodical thinking, planning, and outlining, it is not always easy to find the right words and the best way to introduce the subject to a particular set of readers.

There is one standard rule for writing the introduction: it should be independent of the problem statement and written as if the latter never existed. Moreover, in preparing the introduction, there must be far more sensitivity to reader interest than in the problem statement. More details about the objectives and background must be included. Conventional information elements included are (Michaelson, 1982, pp 37-38):

- The purpose of the manuscript
- A definition of the engineering problem
- The background of previous work in this field, including different approaches
- The chief contributions of others

- The scope of the manuscript
- The rationale for the project
- A brief indication of the technical contents to follow

2.5.2.7 Solutions (Past and Existing)   See Chapter 1, Sections 1.4.1 and 1.4.2 of this report.

2.5.2.8 Alternate Solutions See Chapter 1, Sections 1.1.3.3 and 1.1.3.6 of this report.

2.5.2.9 Constraints on the Solution Constraints that hinder or effect the solution should include such areas as the technical, economic, social, political and environmental. These should be described in as much detail as necessary for an understanding of the solutions utilized in the design.

2.5.2.10 Statement of Work/Method of Solution This is the most important section of the report and should be presented as such. In this section the findings should be presented with precision and clarity. A discussion of the findings should be presented with summary statistics and results of the analyses. Extensive statistical tables should be placed in the appendices with appropriate reference in the text. Charts, graphs and tables should be used to help the reader quickly grasp the information (Sproull, 1995, pp 365).

2.5.2.11 Summary Conclusions are drawn from the findings as they relate to the problem statement, research and objectives of the study. This section consists of interpreting the results of the study according to the acceptable research knowledge and practice (Sproull, 365).

2.5.2.12 References Few research studies can be conducted without reference to information gathered from the organization itself or from other sources such as books, journal or census data. Appropriate citations should be made in the text regarding the reference and a list of references should be included (Sproull, 1995, pp 365). The form of this list varies depending on what publishing style is used.

2.5.2.13 Appendices The appendices might include copies of the instruments, instructions to interviewers, statistical information which is too lengthy to place in the text or drawings of physical layouts. Any information which is extensive or which will be read by only a small number of people should be included.

2.5.2.14 Qualifications of the Engineering Team As mentioned earlier in this report, most funding for design projects have the potential of being targeted by several different groups. This section should illustrate clearly and completely the qualifications held by the engineering team presenting the report.

2.5.2.15 Budget for Engineering Services The design team should carefully construct the work done and the time and funding necessary to cover it.

2.5.2.16 Schedule of Work Completed See Chapter 1, Section 1.1.3.9 of this report.

2.5.3 Graphics in the Final Report Another refinement in the final report is the use of graphics to illustrate engineering concepts or designs. Drawings or photographs can give strong support to the structure of the report, but their effectiveness depends, of course, on how they are designed and where they are used. The best graphic aids are those styled to serve on of five definite purposes (Sproull, 1995, pp 45):

- To describe a function
- To show the external appearance
- To show internal structures (cutaways and exploded drawings)
- To illustrate a phenomenon
- To demonstrate relationships
- To define novelty and originality

2.5.4 Tables in the Final Report The table is another useful device for supporting the structure of the final report. Lists of tabular data can clarify, emphasize, and even dramatize information in ways that cannot be done in the body of the text. When properly constructed, the rows and columns of information in a table permit easy comparisons and interpretations of trends. Like photographs and drawings, tables are an asset only if carefully designed.

2.5.5 Appendix to the Main Body of the Final Report The appendix provides a much different kind of aid to the structural qualities of the manuscript. By omitting certain kinds of information from the main sections and placing them in the appendix, the structure and readability of the more important portions of the manuscript are strengthened. The appendix may contain reference data that are too detailed for some readers but are welcomed by others. Another useful feature of the appendix is the flexibility it lends to the length of a paper for publication.

2.6.0 Conclusions Design engineers must be creative people, able to try one idea after another without becoming discouraged. In general, they learn more from their failures than from their successes. Final designs will usually be compromises and departures from the "ideal" initially sought. Certain design precepts and methods can be learned by study, but the ability to design cannot be gained solely by reading or studying. Engineers must also grapple with real problems and apply their knowledge and abilities in finding solutions. Just as an athlete needs rigorous practice, so engineers need practice on design problems to gain proficiency in the art. Such experience can be gained with the freshman design project.

Figure 2-1: The Problem

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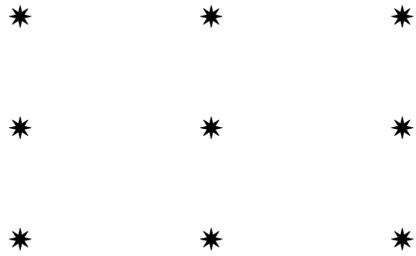
Figure 2-2: First Solution

✳   ✳   ✳

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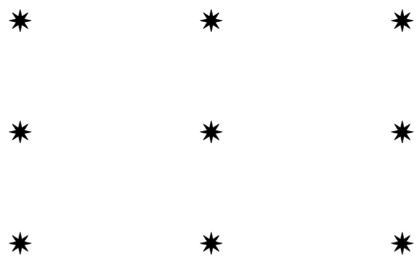
Figure 2-3: Second Solution

✳   ✳   ✳

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✳   ✳   ✳
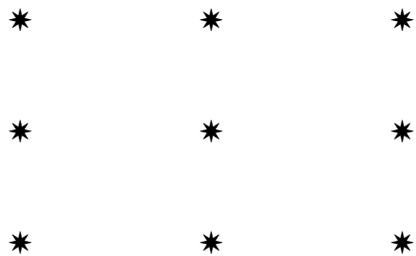
CHAPTER 3

DESIGNING A DESIGN COURSE - ISSUES AND MODELS

James Mitchell, AIA

3.0 Introduction & Purpose

Just as the practice of design varies greatly, the ways in which it can be taught also vary (Sullivan et al., 1994). A useful format is presented here for those charged with creating or modifying an Engineering Design Course. The goal is to define issues that should be considered, present several models for a design course, and then systematically examine the implications of each model for each issue.

The starting point for this discussion is the paper by Shepard and Jenison (1996) which surveys a number of Freshman Design programs, presents desired outcomes, and considers design experiences using two major dimensions (group vs. individual, and technical content vs. process). Wherever possible their terminology is adopted or extended.

Whereas Shepard's approach is primarily pedagogical, the practical or logistical aspects of the process are the focus here in the belief that they often have an important impact on the outcome.

3.1 Definition of Engineering Design and Steps of The Design Process

Shepard uses a definition of engineering design taken from Dym (1994) which is adopted here "Engineering design is the systematic, intelligent generation and evaluation of specifications for artifacts whose form and function achieve stated objectives and satisfy specified constraints."

As with Engineering Design generally, there are many possible steps in a design process. For this discussion the following eight used by Shepard are adopted. They are "establishing objectives and criteria, generating alternatives, synthesizing, analyzing, constructing, testing and evaluating."

3.2 Issues for Design Courses

There are several issues which a course designer would be wise to consider during development. None of these should be startling to the reader, nonetheless making them explicit with comments should be helpful. It should not be surprising that the approach taken here is very much what we teach in a design project. In essence, the problem and constraints are defined as well the techniques which will be used to produce the final product. This definition does not explicitly include interactions with other individuals important to the creation process (financial, code etc. representatives). It also needs to be extended to include non-physical products such as process design. Another, preferred definition would be "Any process whereby a new or modified product is defined relying, at least in part, on the unique technical knowledge

and skills of an engineer." As with the start of a design problem, there is not necessarily a "right" order, although the order given is often logical.

3.3 Players and Their Characteristics

When starting the design of a course the natural inclination is to assume that there are only two important players in the process: students and faculty. Experience shows that there are others who can be extremely important in the success of a design course.

3.3.1 Major Players

Students

This is the most obvious group. Considering their range of characteristics is certainly important.

Faculty

Who is available to develop and teach the course and what are their characteristics? Since some design courses make an attempt to coordinate their work with other courses it may also be important to consider the faculty in those other courses.

Administration

The departmental or university administration is often more important than in standard courses since there are often issues in design courses which require administrative support - teaching credit, resources etc.

Support Staff

The availability, experience, attitude and numbers of support staff such as laboratory technicians, teaching assistants, machinists, etc. can be of critical importance, particularly when students are expected to construct products.

Industry

Industry support can be very useful in developing a design process. They can play roles ranging from actually teaching to providing materials and fabrication capability, to funding.

Alumni

As with industrial support, alumni can be highly valuable as technical resources and potentially as advisors to students.

Audience Characteristics

For each aforementioned audience it is worth considering the following characteristics of the individual or group:

Experience

What experience do they have relevant to the course. For each of the major players the specific experience will vary, but nonetheless matters.

Ability

What abilities do they bring. In the case of students and faculty these may be technical capabilities. In the case of other players they may be resources under their control

Uniformity vs. Diversity

How uniform is the group. If one can assume uniformity then a single approach may suffice. If the group is diverse then a multiplicity of approaches may be required.

Expectations

What expectations do these players bring to the course. Recognizing these expectations and ensuring that the process of creation addresses them can make the difference between success and failure.

3.4 Learning Goals - the Pedagogy

This area receives most of the attention in Shepard & Jenison's paper. It addresses 16 different "qualities" that they believe can be important to impart as the result of the design process which leads to their decision to evaluate design courses on two different axes. The first axis is individual vs. group effort. The second is technical content vs. student "qualities" development. They chart the experience over the entire curriculum by displaying the design courses in the resulting quadrant created by the crossed axes during each year.

3.4.1 Technical Content Shepard & Jenison characterize this as "domain-specific" knowledge and content. Characteristics of these courses are: achievement of goals can be measured with conventional exams, subject matter is consistent from year to year, the course is product-oriented ("final artifact," "right answer"), the teaching method is instructional in nature (lecture-practice-lecture-practice), it is relatively easy to "take the pulse of the class" to see if they are "getting it," and a textbook is generally available. Examples include traditional engineering science courses such as strength of materials, dynamics, as well as most calculus and science courses."

An important decision when considering Technical Content is how closely to the requirements or perceptions of a particular engineering discipline the course is expected to conform. Experience shows that the expectations of different disciplines vary greatly. Some value a highly structured approach emphasizing goals and criteria definition. Others emphasize analysis or testing.

3.4.2 Attitudes or "Qualities" On the same axis but at the other pole from technical content, Shepard & Jenison put qualities having the characteristics of: "open-ended" problem solving, achievement of goals rarely measurable with conventional exams (and which may require observational methods such as ethnography, longitudinal "snapshots" such as portfolios, or reflective methods such as journals), subject matter not the same from year to year, a process/method-oriented course, teaching methods experiential in nature (experience-lecture-exercise-reflection), where it is difficult to "take the pulse of the class" in a quantitative manner to see if the students are "getting it," and a textbook is generally not available.

3.4.3 Group Work vs. Individual Work Shepard & Jenison presents this as an important dimension because it "reflects whether a student sees him- or her-self as an individual learning a

body of knowledge and/or gaining competency, or as part of a team that is collectively responsible for learning, sharing and utilizing knowledge. There are persuasive arguments that can be made for both approaches; individual assignments allow for greater assurance of individual accountability and competency, while team-based learning may better reflect the work world, allows students to feel less isolated in their learning, and presents multiple representations of knowledge."

3.5 Scope & Integration

In addition to the important Learning Goals considered above the following pedagogical issues can beneficially be explored.

3.5.1 Steps of Design Process An important initial decision is how many of the eight possible design steps outlined above are to be explored in the design course and to what depth each will be considered. This is a decision often made by default rather than explicitly. The relative importance of each of the steps may be considered quite differently within different engineering disciplines. For some disciplines, for instance, ensuring that a design is carried to the point of testing is essential, while in others it may be considered unfeasible (e.g. in large-scale civil engineering projects).

3.5.2 Time Extent How much time is to be devoted to the various ingredients of the design course? Some steps of the design process can be accorded 15 minutes or 15 days equally well, while others have certain minimum times to be useful. Similarly the course developer must consider whether there are to be multiple "small" projects, a single large one, or some mix of these approaches. The questions that a developer may ask include:

- How many projects are desirable?
- How long should each last?
- Should some be simultaneous?
- How many hours of student effort are required?
-

3.5.3 Discipline Extent Most "real world" design projects cross many discipline bounds including disciplines outside engineering. Again, this decision is often made by default, but when considering the course plan the designer would beneficially ask the following questions:

- Should non-engineering issues be included? If so, how?

- Within engineering should projects be limited to a single discipline?

3.5.4 Observation vs. Performance A key assumption in many design courses is that the only way to learn design is to "do it". There are other alternatives which may play a role and should be considered for at least a partial role.

- Lecture about the design process.

- Students observing the design process either by watching a design in process or by case studies.

- Limited performance of design steps. Performing design steps following some sort of a "script" to internalize the procedures and understand the experience while still following a pre-determined overall path.

- Fully open-ended design in which the student learns by performing the entire set of selected design steps in the same fashion as in industry.

3.5.5 Feedback Goals The desired frequency and type of feedback provided to students (and faculty) can have important consequences. The types of feedback can include:
- Oral or written evaluations by faculty, peers, self or outside experts

- Product testing - analytically, simulation or physically

- Role playing (for some design steps)

- Process simulation using Computer Software (The possibilities of developing software which leads students throught design steps and shows them the implications of decisions seems to be very great and not well explored as yet. Developing a "general" approach is undoubtedly impossible, but it ought now to be possible with subsets of the design process and within certain disciplines. This would be the equivalent of the "build your own company" simulations used in business school curricula.)

The frequency with which feedback is provided can be equally important. It can range from immediate and continuous as in role playing or simulation situations, to unitary if the only thing evaluated is the final project.

Also, the specificity of feedback can become vital. It may range from general comments about the results of a large number of students (often with examples), down to one-on-one discussion with each student about every aspect their progress. The implications of this decision on the design faculty's time are enormous.

3.5.6 Integration with Other Courses Is this course going to be integrated with other courses either concurrently or sequentially? Is there a desire to establish a sequence of experiences for students or is the course to be self-contained?

3.6 Administration & Logistical Concerns

More than in most courses the "practical" issues become extremely important in determining the success of a design course. They tend to be "messy", often demanding large amounts of time from all of the players as well as demanding of other resources. Some of the major resources are:

3.6.1 Resources

Time of all the players

Particularly if projects are "open-ended" they have a tendency to absorb vast amounts of student time - sometimes at the expense of their performance in other courses. If a "frequent, highly specific" feedback model is adopted the demands on faculty time can be enormous as well. The same can be said about each of the players identified above.

Teaching Credit

An issue directly related to faculty time is that of "credit". When there are individual projects there often appear to be difficulties recognizing the faculty effort in the institution's tracking system since it is usually set up to recognize only full courses. If this issue is not resolved it can lead to justifiable complaints by faculty that there is no reason for them to teach a design course since it is not "counted" by the institution.

Technician & Shop Time

While this is a specific instance of the general time issue, it can become particularly important in a design course. Technician and shop time is usually scarce and allocated to support of research efforts, to build demonstration apparatus or to set up for demonstration preparations. An unexpected deluge of students on a tight schedule needing assistance can create a disaster.

Money

In a design course there are likely to be far more needs for additional money than in a normal course. These needs can include:

- Materials for projects
- Fabrication of models or prototypes
- Student travel to sites or to bring in outside visitors
- Publications highlighting products
- Awards for competitions

Space

There may be significant space needs during the life of a design course. They may include space for:

- Prototype or model assembly
- Presentation practice as well as delivery
- Testing of products
- Team meetings

Computers & Peripherals

As with technician and shop time there may be a marked spike in the demand for computers and their peripherals. These demands should be anticipated. The types of needs include:

- Actual compute cycles for modeling and CAD
- Workstation access for groups or individuals
- Scanners, video equipment etc. for data gathering
- Printers, projectors etc. for presentations and report preparation.

3.6.2 Scheduling & Coordination The "messiness" of design courses is often seen in the scheduling and coordination issues that they raise. Issues beyond the normal course scheduling which a course designer might anticipate include:

- Classroom availability for extended periods for activities such as testing or presentations

- Matching students or teams with faculty or TA mentors for advising and feedback sessions

- Shop, lab and computer facilities access - often at strange hours.

- Coordinating project due-dates with instructors of other courses to enable students to attend presentations, perform testing etc. and to avoid conflicts with major examinations in other course.

- Syllabus coordination with other courses if activities in the design course are to be coordinated with those other courses.

3.7 Assessment

The issue of assessment is a major one and is dealt with some depth elsewhere. Only some of the possible issues which may flow from the discussion above and the audiences for the assessment are presented here. The assessment almost certainly needs to be both formative and summative in nature.

3.7.1 Assessment Audiences There can beneficial assessment for each of the audiences mentioned above. For students and faculty the most important is the formative assessment which allows corrections during the duration of the course. For other players the summative measures which reassure them of the value of their contribution are probably more important. Of particular importance is the addition of the Accreditation Board for Engineering and Technology (ABET) as an audience through its ABET-2000 criteria.

3.7.2 Assessment Items It is easy to argue that each of the issues presented previously should be identified and measured as part of a design course. Most effort understandably focuses on student learning.   The additional summative measures that follow might be particularly relevant for a design course:
- Resource requirements, both absolute and per student:
- Faculty and student time, both absolute and per student:
- Industry evaluation of design process and product

3.8 Design Teaching - Five Models

As suggested previously, there are five basic models for teaching design. In this section we will describe some of the relevant characteristics of each approach and then use the issues described above to consider implications of each model for each issue. For a subject as broad

as "design" there will undoubtedly be exceptions to almost every statement made. The intent is consider most cases in order to assist in course design rather than be exhaustive.

3.8.1 Basic Models

Lecture Series

Most design instructors shy away from the lecture as a tool on the assumption that students will not gain actual abilities at design. Used exclusively that is almost certainly true, but the lecture has a place when talking about general principles or giving case studies. Since its utility and requirements are generally understood we will not consider it's implications for each issue as we will for the other models. By lecture we would also include "canned" materials not requiring immediate student interaction during the presentation. This would therefore include videos, slide shows, etc.

Case Study

Presentation of a case study can be highly beneficial to students as an example of the general design process suggested in the course as well as allowing specific exercises associated with a "guided-design" approach. Here we are considering it as essentially a "lecture" which illustrates the points to be made by use of a full example. As such it is really a special case of the lecture and needs no further detailed consideration.

Design Sequence Components

This non-standard term describes any effort to isolate individual or small groups of steps in the design process, focusing on them to develop particular skills. After doing so students are expected to apply them effectively when a larger design problem is undertaken. Examples would be conducting "brainstorming" exercises to develop skill at "generating alternatives". Another example (which in fact fills much of the curriculum) is developing analytic skills.

Since the number of possible exercises is great and will vary considerably between disciplines we will not consider this approach in detail although it can most assuredly be beneficially combined with other approaches when constructing an entire course.

Guided-Design

In a "Guided-Design" approach students are moved through a predetermined design (Wales and Stager 1972). It is like a case study, but rather than being passive, students provide their own input at selected stages during the design. Those inputs are compared to the solution(s) chosen or demonstrated by the professional to provide feedback. Students then proceed to the next stage adopting the professional's solution as the starting point for their efforts. In this way students have the opportunity to be both "open-ended" and to follow an overall track. This approach does not appear to be widely used currently for reasons that are unclear, nonetheless it is an option, particularly when considered with the possibilities offered by computer-based training.

Open-Ended Design

"Open-ended" design is the model most often thought of when considering a design course. It mimics what is seen to be the typical design process in industry, asking students to perform more than one of the eight design steps in sequence. The expectation is that there will be many variations in the product generated with no "right" answer. Students may all start with a common problem or may be required to generate their own. The product may be anything from a problem statement to a working prototype and the time involved may be anything from five minutes to multiple years.

Since there are noticeable differences between short and long open-ended design projects we will here consider them separately. "Short" design projects will be assumed to be a week or less in length and "long" ones will be more than a week.

3.8.2 Description To consider the implications of these models we will present two tables allowing comparisons and detailed consideration. First we present a summary table of all the models with general notes about their applicability in the Logistic and Pedagogical areas. Then, for guided and open-ended design we'll consider the implications for each of the many issues defined earlier.

Summary Table

Model Name	Pedagogical Issues	Logistic Issues
Lecture	Limited student participation - Essentially passive environment. Thus very difficult to test design skills. Excellent for communicating specific information or demonstrations to large numbers of students efficiently. Allows use of scarce resources such as "famous designers" for inspiration. Uniformity of information transmitted.	Highly efficient from an administrative point of view. Easily scheduled.
Case Study	Similar to lecture Particularly useful for illuminating general principles with specific examples for those whose learning style need that sequence.	Similar to lecture

Design Sequence Components	Allows focus on individual steps of the design process and thus associated techniques for addressing those steps. Difficult to make connections to the overall design process. Enormous variety of possible approaches depending on the number of steps.	Varies too greatly to generalize.
Guided-Design	Allows common experience for large group of students while still allowing them to develop their own ideas at each step. Ensures that students see the entire sequence. Prevents difficulties arising from compounding errors made by students at an individual stage.	Demanding for the instructor to develop the material and vary it sufficiently to avoided plagiarism problems. Requires a very skilled instructor to deal effectively with large groups. Could have some of the same resource issues for extended problems as open-ended design approaches.
Open-Ended Design	Models the "real world" more or less closely to the extent that the full number of design steps are included. Well suited to developing the "qualities" recommended by Shepard. Lends itself to work with industry on real problems. Difficult to evaluate uniformly because of the variety of products and the large number of faculty involved.	Requires instructors with design expertise - often not the case with engineering faculty. Many engineering programs have experience with this approach thanks to "capstone design" programs. Most likely to require additional resources, scheduling etc. Usually requires large number of faculty (low student-faculty ratio) to provide regular feedback to student.

Note in this consideration of detailed issues we do not consider the first three models. As noted previously they do not have enough variation on the issues or are too varied to be considered productively.

Issue	Guided Design	Open-Ended - Short	Open-Ended - Long
Major Players	Most likely to involve only students and faculty although support staff may be required. The characteristics of the players can be important, particularly if group efforts are required, but are probably less important than for open-ended design.	Most likely to involve only students and faculty although support staff may be required. Characteristics of the players, particularly students, will make a large difference in the success of the project, particularly when group efforts are required. The short nature of the project allows adjustments between projects to resolve difficulties during the progress of a course.	Most likely to involve all possible players - faculty, students, administration, support staff, Industry, Alumni. Failure to account for differences may have a larger effect since the projects last longer.
Technical Content (note that often be covered by lectures and individual exercises too)	Probably the easiest to control in terms of students covering specific technical content since the design "restarts" at the end of each step of the design process.	Probably the most difficult model with which to control student's technical content since so much effort is likely to be taken up with non-technical issues such as group management, presentations etc.	Offers the greatest opportunity for considering technical content in depth because of the extended time. Simultaneously offers the greatest opportunity to waste time and not address technical issues if a schedule is not maintained.

Attitudes or Qualities	May be imparted if specific exercises are incorporated during the process. However, the overall design experience is probably not as well simulated as with open-ended design.	Can be imparted by the structure of the exercise, with emphasis on different aspects. The short nature may actually enhance certain types of qualities by the intense nature of the process.	Offers the greatest scope for developing qualities, but depends on the faculty advisor in large part. Also offers the greatest danger of failures in one area spoiling learning in other areas - e.g.. group processes.
Group Work vs Individual Work	Can accommodate either.	Can accommodate either. Often use groups because a large amount can be accomplished in a relatively short time.	Can accommodate either. Again groups are often desirable because they are so much the pattern in industry and for the benefits of multiple skills.
Steps of Design Process	Can model any or all of the steps. Gives greatest control over sequence to ensure that all participants have the same experience.	Typically some of the design steps are eliminated or elided. More difficult to observe and comment on the separate steps because of the speed of the process.	Offers the fullest possibilities for experiencing and reflecting on all of the design steps.
Time Extent	Will accommodate either short or long projects although shorter ones seem more likely.	By definition this is a relatively short project. The benefit, naturally, is that more different types of projects using various formats may be undertaken within the confines of a single course.	Again by definition this is "long" - and therefore limits the total number of approaches to learning design.

Discipline Extent	Theoretically this should give the most flexibility to include cross-discipline work in a structured manner.	Cross-discipline work is fairly rare using this approach because of the difficulties of coordinating schedules of different disciplines.	Cross-discipline work is fairly rare using this approach because of the difficulties of coordinating schedules of different disciplines.
		In Freshman projects it may be possible to assign disciplines to the students, but they do not yet have discipline skills and knowledge.	It should be more possible in Capstone Design projects, but will require structuring of the projects by faculty and extra coordination efforts.
			In Freshman projects it may be possible to assign disciplines to the students, but they do not yet have discipline skills and knowledge.
Observation vs Performance	This approach combines the possibility of both performance and observation. Students can perform a step and then observe how a professional performs the same work.	The effort is virtually all on performance. The only "observation" typically comes when attending presentations and commenting on them.	The effort is virtually all on performance. The only "observation" typically comes when attending presentations and commenting on them.
Feedback Goals	Allows rapid feedback on the steps through the performance-observation process as well as the usual grading and/or instructor comments.	Feedback typically comes through evaluation of the final project and perhaps through comments on journal or notebook entries. In Freshman Design feedback often comes through some sort of public competition or display.	Feedback comes mostly through regular meetings with faculty advisors, journals or notebooks. In addition there is typically a major document and presentation as well as demonstration of a prototype.

Integration with Other Courses	Probably not likely, although the better-defined scheduling should make it more possible than in the longer open-ended design process.	Typically difficult to coordinate simultaneous integration except through humanities participation with journals. Offers the possibility of assigning projects which draw on technical material considered in other courses.	Typically difficult to coordinate simultaneous integration except through humanities participation with journals.
Time of all the players	Relatively easy to control duration and timing, but still open to very large demands on all participants (although alumni and industry are be less likely to be involved).	May have very intense demands during the process, particularly for students, but also for faculty and support staff.	Likely to have the greatest overall demands on all players, with considerable peaks and valleys.
Teaching Credit	Relatively easy to control since this approach is probably contained within a regular class with a limited number of instructors.	Relatively easy to control since this approach is probably contained within a regular class with a limited number of instructors.	The large number of faculty likely to be involved as group advisors is very much subject to the concern of "lack of credit".
Technician & Shop Time	Could be required, but probably not in most cases.	Could have very heavy demands depending on the type of project picked.	Most likely to have heavy demands, again with peaks and valleys.

Money	Least likely of these approaches to generate additional demands although it is a possibility.	Projects involving "build-it" efforts are likely to require significant support. These projects are typical of Freshman Design.	Most likely to generate significant expenses for materials, travel, reproduction etc. Student groups often also are willing to bear the expense because of their intense involvement. Involving industry and alumni can assist greatly with these expenses.
Space	Least likely of these approaches to generate additional demands although it is a possibility.	Projects involving "build-it" efforts are likely to require significant space for construction, testing and display. These projects are typical of Freshman Design.	Projects involving "build-it" efforts are likely to require significant space for construction, testing and display. Some schools also feel it important to provide working space for design groups.
Computer & Peripherals	Likely to generate large peak demands for these facilities.	Likely to generate large peak demands for these facilities.	Likely to generate large peak demands for these facilities as well as longer term demands.

Scheduling & Coordination	Least likely to require major scheduling efforts unless there are construction requirements as part of the project.	Scheduling issues may arise from the desire to display results in a large forum, leading to a desire to free up significant blocks of time. Other courses, particularly in Freshman year, often need to be coordinated because the student focus on the design project leads to decreased time for other work. Computer, Shop, workspace and lab coordination may become very important.	Scheduling issues arise from the desire to display results in a large forum, leading to a desire to free up significant blocks of time. Other courses often need to be coordinated because the student focus on the design project leads to decreased time for other work. Computer, Shop, workspace and lab coordination may become very important.
Assessment Audiences	Typically the audiences are primarily within the class although overall course assessment is always important.	Typically the audiences are primarily within the class although overall course assessment is always important.	Because of the potential heavy involvement of faculty time and resources as well as the project's relationship to industry these projects are often important to assess industrial audiences as well. ABET will also take a particular interest in longer projects because of their larger importance within the curriculum.

Assessment Items	This approach probably requires the most standard assessment items unless there are heavy resource demands. Items as journals and logbooks can be very useful in this type of project.	The assessment items are more unusual than for guided design, but the short project duration will typically limit them. Items as journals and logbooks can be very useful in this type of project.	Because of the potential heavy involvement of faculty time and resources significant effort should be put into many assessment items (although currently it often is not in Capstone courses). Items as journals and logbooks can be very useful in this type of project.

3.9 Conclusions

The models and issues presented above will hopefully aid an individual charged with developing a design course. If one decides to treat the process itself as a design problem it may be helpful to use Shepard & Jenison (1996) to establish goals and a more detailed consideration of the issues presented here to establish constraints. As with any design process it will undoubtedly be iterative, but there is hope that these guides may reduce the number of cycles.

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APPENDIX A

Forms Used in Freshman Design Program

Topic Approval Form
Proposal Guidelines
Proposal Format (Cover Page)
Equipment Request & Advisor Availability
Freshman Design Presentation Form
Final Report Guidelines
Final Report Format (Cover Page)

<u>A FINAL REPORT</u>

SUBMITTED TO   _____

                           _____

{names of faculty adviser(s)}

AND THE

ENGR 130 PROJECT DESIGN FACULTY OF DREXEL UNIVERSITY

ENTITLED: _____

                        _____

                        _____

TEAM MEMBERS/DESIRED CURRICULUM (e.g. A.E., C.E., E.C.E., Etc.):

Team Members	Curriculum (AE,ECE,etc.)	Humanities Advisor
_____	_____	_____
_____	_____	_____
_____	_____	_____

Submitted in partial fulfillment of the requirements for

The Engineering Design and Laboratory, ENGR 130, Design Project

Submitted on   _____

{date}

ENGR 130, ENGINEERING DESIGN AND LABORATORY
FINAL REPORT GUIDELINES

A FINAL REPORT

a.) **PRINT ON 8.5" X 11" PAPER**, one side of the sheet only; place in a binder with a clear cover showing the title page

b.) **THE REPORT** should not exceed 10 pages, excluding the appendices, only as needed. (Note that the executive summary is a separate page and does not count in the 10 page limit)

c.) **SUBMIT COPIES OF THE FINAL VERSION OF THE FINAL REPORT BY** Friday, May 31,1996 at Noon as follows.

    a. At least one copy to each team adviser;
    b. One copy to Ms.Eileen Currie, Room 3-261 { the **ORIGINAL** or a copy of **GOOD QUALITY**,
        For the college's Freshman **DESIGN LIBRARY**)

(IF THIS COPY IS NOT SUBMITTED, NO GRADE WILL BE REPORTED
FOR THE TERM)

d.) **CONTENT**:
    a. **COVER LETTER OF TRANSMITTAL**- to adviser;
    b. **TITLE PAGE**- must follow the format of the "Final Report Title Page', available on the E^4 fileserver;
    c. **ABSTRACT**- no more than 150 words (one page limit), on a separate page of the report;
    d. **EXECUTIVE SUMMARY**- a separate, one page document whose audience is a non-technical executive with decision power;
    e. **TABLE OF CONTENTS**- list all sections of the report, the appendices, and figures, etc with page numbers;
    f. **INTRODUCTION**- should include:
        i. PROBLEM BACKGROUND
        ii. SURVEY OF THE LITERATURE
        iii. PROBLEM STATEMENT/OBJECTIVES
        iv. CONSTRAINTS OF THE SOLUTION
        v. CRITERIA USED IN THE SOLUTION

    g. **THE SOLUTION**- should address:
        i. STATEMENT OF WORK(ALTERNATIVES CONSIDERED)
        ii. RESULTS- THE SOLUTION

FRESHMAN DESIGN PRESENTATION FORM

ENGR 132 – ED&L: (After completing this form, please hand it to the group's faculty technical advisor.)

ROOM # : _____ **TIME :** _____

FACULTY TECHNICAL ADVISOR: _____

PROJECT TITLE: _____

ORAL PRESENTATION SCORES:

1. **INTRODUCTION:**
Problem background, clarity of problem statement, expression of the necessity of project, etc   (20 pts.max)

_____

2. **METHOD OF SOLUTION:**
Survey of literature ,activities completed to obtain solution,etc.   (20 pts max)

3. **RESULTS/CONCLUSIONS:**
Solution of problem as stated, compatibility of solution with potential applications, range of alternatives examined, effects of errors in analysis, or measurement, justification for judgments and assumptions, etc
          (20 pts. Max)

4. **TEAM WORK:**
Introduction of team members, support for one another, attention to team member's presentations, all members contributing, etc.   (20 pts.max)

5. **MECHANICS OF PRESENTATION:**
Response to question/ answer session, preparation, timing, appearance and poise of speakers, use appropriate visual aids, etc.
          (20 pts. max)

TOTAL   (100 pts max)

REVIEWER'S NAME _____

GENERAL COMMENTS: _____

_____

ENGR 130, ENGINEERING DESIGN AND LABORATORY EQUIPMENT REQUEST AND ADVISOR AVAILABILITY

PROJECT INFORMATION

ENTITLED: _____

_____

_____

TEAM MEMBERS/ DESIRED CURRICULUM (e.g., A.E.,C.E,E.C.E, etc.);

_____   _____

_____   _____

_____   _____

ADVISOR INFORAMTION

ADVISORS:, _____   **TECHNICAL ADVISOR**

{*signature*}

ADVISOR _____   **HUMANITIES**

TIMES WHEN ADVISOR(S) WILL _NOT_ BE AVAILABLE FOR YOUR PRESSENTATION:

TECHNICAL ADVISOR 27th _____

28th _____

HUMANITIES ADVISOR 27th _____

28th _____

EQUIPMENT INFORMATION

A/V EQUIPMENT NEEDED FOR PRESENTATION:

_____

**Submitted in partial fulfillment of the requirements for
The Engineering Design and Laboratory, ENGR 130, Design Project**

Submitted on _____

A PROPOSAL

SUBMITTED TO _____

_____

{names of faculty adviser(s)}

AND THE

ENGR 130 PROJECT DESIGN FACULTY OF DREXEL UNIVERSITY

ENTITLED: _____

_____

_____

TEAM MEMBERS/DESIRED CURRICULUM (e.g. A.E., C.E., E.C.E., Etc.):

_____   _____

_____   _____

APPROVED BY: _____

,**TECHNICAL ADVISOR**

{signature}

ADVISOR _____, **HUMANITIES**

{signature}

Submitted in partial fulfillment of the requirements for
The Engineering Design and Laboratory, ENGR 130, Design Project

Submitted on _____

{date}

PROPOSAL GUIDELINES

A PROPOSAL

1. **Title Page-**Follow the format of the "Proposal Title Page" - it can be found on the TDEC fileserver.

2. **Introduction to the Problem or the Problem Background -** General background to the problem and problem situation. Establishing the need and identification of the relevant problem.

3. Survey of the Literature - a brief overview, with commentary, of what is in the professional literature regarding the problems) you've identified above and the adequacy of any existing solutions to those problem(s).

4. **Problem Statement** - Precisely what problem are you going to try to solve.

5. **Statement of Work/Method of Solution** - Describe exactly what you will do to obtain a solution. For example:

   a.) How will you do it?

   b.) Where will you do it?

   c.) Will you perform experiments? Will you build on any unique principles, etc.?

   d.) What type of existing systems relate to your problem and the solution method?

   e.) What alternative solutions will be considered?

   f.) How are you going to evaluate and choose between alternatives? Criteria?

6. **Timeline** - critical dates for phases of the project;

7. **References** - list in order of appearance in your proposal, with citation numbers, e.g. [5]; refer to the Holt Handbook for form;

8. **Proposers' Background/Vitae**

GENERAL COMMENTS

   I. Choose a faculty member from any engineering or science department as your team's adviser.(W**ith their prior approval!)**

   2. The length of the proposal should not exceed 5 pages plus vita and appendices. It must be done with a Macintosh word processor, which allows you to modify the documents for use later, such as in the final report.

   3. Print on 8.5" X 1 I" paper, one side only; place in a binder with a clear cover showing the title page.

ENGR 130, ENGINEERING DESIGN ANDLABORATORY
TOPIC APPROVAL
Request for team project design topic approval

The following
Students:

	NAMES	CURRICULUM (CE,EE,etc.)	PHONE Nos	E-MAIL ADDRESS
1.				
2.				
3.				
4.				
5.				

request the design faculty's approval of a TDEC team design
project entitled:

[PRINT THE TITLE] ———————————————————————

BRIEF ABSTRACT: ———————————————————————

(Continue on other side if necessary)

to be done under the
supervision of:

———————————————————

(Technical Advisor)

———————————————————

(Humanities Faculty)

———————————————————

(Associate Advisor(s) Optional)

APPROVAL

TECHNICAL ADVISOR ————————————————   ————————————

(signature)   (Date)

READ THE FINE PRINT:
The advisor must sign this form and be given a copy; the SIGNED ORIGINAL must be filed with the TDEC Design
Coordinator,
Dr. J.R.WEGGEL- MAIN/CUTIS, ROOM 270

H. **<u>DISCUSSION AND CONCLUSIONS</u>** - errors, validity, assumptions, costs, benefits, etc.

I. **RECOMMENDATIONS FOR FUTURE WORK** - a guide to others who continue the project;

J. **<u>REFERENCES</u> -** list in order of appearance in your document, with citation numbers, e.g. [5]; refer to
    the *Handbook of Technical Writing;*

K. **<u>ACKNOWLEDGEMENTS</u> -** of assistance, support, etc.

L. **<u>APPENDICES</u> -** only if needed to fully document report background, calculations,computer program listings, etc.

NOTE: Stress must be placed upon proper <u>drawings</u> and <u>icp</u> <u>torial sketches</u> to fully *explain and communicate the final results of the project.*

APPENDIX B

Assessment Forms, 1997-98 Academic Year

Form E1 - Engineering Faculty Review, Problem Definition
Form E2 - Engineering Faculty Review, Proposal
Form E3 - Engineering Faculty Review, Oral Presentation
Form E4 - Engineering Faculty Review, Final Report

Form H1 - Humanities Faculty Review, Problem Definition
Form H2 - Humanities Faculty Review, Proposal
Form H3 - Humanities Faculty Review, Oral Presentation
Form H4 - Humanities Faculty Review, Final Report

E1	Drexel University

Drexel University

Freshman Design Project

Faculty Review - Problem Definition

The purpose of this assessment is to afford faculty and their students an opportunity to review and evaluate the acquisition and demonstration of specific knowledge and skills. This review will take place at the conclusion of the *Problem Definition* phase of the Freshman Design Project. The faculty member's assessment will be recorded on this review form. A copy of the completed evaluation will be given to the student team as additional feedback on their performance.

Please provide the following information:

			Special Comments:
Course Section			
Term/ Date			
Instructor/ Advisor			
Team ID			
Student Name			
Student Name			
Student Name			
Student Name			
Student Name			

*Generally, all students on the team should receive the same grade unless the instructor/advisor is aware of circumstances that indicate a student has earned a higher or lower grade than his/her team mates. Note rationale under special comments above.

Throughout this phase of the project, the team demonstrated the following CORE knowledge, skills, and abilities:	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
Analytical Skills *Applies logic in solving problems and analyzes problems from different points of view. Translates academic theory into practical applications using appropriate technical techniques, processes, and tools.*	1	2	3	4	5
Communication Skills *Articulates ideas in a clear and concise fashion and uses facts to reinforce points. Written materials flow logically and are grammatically correct. Plans and delivers oral presentations effectively. Uses technology and graphics to support ideas and decisions.*	1	2	3	4	5
Creative Problem-solving *Suggests new approaches and challenges the way things are normally done. Develops many potential solutions to problems while discouraging others from rushing to premature conclusions.*	1	2	3	4	5
Life-Long Learning *Learns independently and continuously seeks to acquire new knowledge. Exceeds basic requirements of an assignment and brings in relevant outside experiences to provide advanced solutions to the problems at hand..*	1	2	3	4	5
Project Management *Sets goals, prioritizes tasks and meets project milestones. Seeks clarification of task requirements and takes corrective action based upon feedback from others. Creates action plans and timetables to complete assigned work.*	1	2	3	4	5
Research Skills *Uses computer based and other resources effectively thus acquiring information from multiple sources. Organizes and interprets data appropriately. Designs and conducts experiments to validate theories.*	1	2	3	4	5
Systems Thinking *Understands how events interrelate and demonstrates an ability to take new information and integrate it with past knowledge. Integrates and uses knowledge from various courses, including Engineering, Physics, Mathematics, and Social Sciences, to solve technical problems.*	1	2	3	4	5
Teamwork *Each member contributes a fair share to the completion of the project. Everyone participates, listens and cooperates with other members. Members share information and help reconcile differences of opinions when they occur.*	1	2	3	4	5

Technical Competencies

Throughout this phase of the project, the team demonstrated the following TECHNICAL knowledge, skills, and abilities:	Not Applicable	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
Discusses the need for the proposed design in an objective and realistic manner. Presents research that demonstrates need for the proposed design.	N/A	1	2	3	4	5
Identifies and evaluates what, if anything, currently satisfies the need addressed by the proposed design.	N/A	1	2	3	4	5
Uses rational, objective reasoning(common sense) to select from among alternative ways to satisfy needs.	N/A	1	2	3	4	5
Identifies constraints/limitations which may be encountered on project.	N/A	1	2	3	4	5
Anticipates the performance of the design in an objective manner and does not make unsubstantiated claims.	N/A	1	2	3	4	5
Projects ways of evaluating effectiveness of final design.	N/A	1	2	3	4	5

Comments

Drexel University

E2

Freshman Design Project

Faculty Review - Proposal

The purpose of this assessment is to afford faculty and their students an opportunity to review and evaluate the acquisition and demonstration of specific knowledge and skills. This review will take place at the conclusion of the *Problem Definition* phase of the Freshman Design Project. The faculty member's assessment will be recorded on this review form. A copy of the completed evaluation will be given to the student team as additional feedback on their performance.

Please provide the following information:

Course Section		
Term/ Date		
Instructor/ Advisor		
Team ID		
Student Name		
Student Name		
Student Name		
Student Name		
Student Name		

Special Comments:

*Generally, all students on the team should receive the same grade unless the instructor/advisor is aware of circumstances that indicate a student has earned a higher or lower grade than his/her team mates. Note rationale under special comments above.

Throughout this phase of the project, the team demonstrated the following CORE knowledge, skills, and abilities:	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
Analytical Skills *Applies logic in solving problems and analyzes problems from different points of view. Translates academic theory into practical applications using appropriate technical techniques, processes, and tools.*	1	2	3	4	5
Communication Skills *Articulates ideas in a clear and concise fashion and uses facts to reinforce points. Written materials flow logically and are grammatically correct. Plans and delivers oral presentations effectively. Uses technology and graphics to support ideas and decisions.*	1	2	3	4	5
Creative Problem-solving *Suggests new approaches and challenges the way things are normally done. Develops many potential solutions to problems while discouraging others from rushing to premature conclusions.*	1	2	3	4	5
Life-Long Learning *Learns independently and continuously seeks to acquire new knowledge. Exceeds basic requirements of an assignment and brings in relevant outside experiences to provide advanced solutions to the problems at hand..*	1	2	3	4	5
Project Management *Sets goals, prioritizes tasks and meets project milestones. Seeks clarification of task requirements and takes corrective action based upon feedback from others. Creates action plans and timetables to complete assigned work.*	1	2	3	4	5
Research Skills *Uses computer based and other resources effectively thus acquiring information from multiple sources. Organizes and interprets data appropriately. Designs and conducts experiments to validate theories.*	1	2	3	4	5
Systems Thinking *Understands how events interrelate and demonstrates an ability to take new information and integrate it with past knowledge. Integrates and uses knowledge from various courses, including Engineering, Physics, Mathematics, and Social Sciences, to solve technical problems.*	1	2	3	4	5
Teamwork *Each member contributes a fair share to the completion of the project. Everyone participates, listens and cooperates with other members. Members share information and help reconcile differences of opinions when they occur.*	1	2	3	4	5

Technical Competencies

Throughout this phase of the project, the team demonstrated the following TECHNICAL knowledge, skills, and abilities:	Not Applicable	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
Identifies and evaluates at least two design alternatives.	N/A	1	2	3	4	5
Applies mathematics to the analysis of design alternatives.	N/A	1	2	3	4	5
Applies knowledge of science (physics, biology, and/or chemistry) to the analysis of design alternatives.	N/A	1	2	3	4	5
Uses rational, objective reasoning (common sense) to select proposed design from among alternatives.	N/A	1	2	3	4	5
Anticipates the performance of the design and its components in an objective manner and does not make unsubstantiated claims.	N/A	1	2	3	4	5
Includes the citation of at least four information sources in research.	N/A	1	2	3	4	5
Identifies additional information/data needs.	N/A	1	2	3	4	5
Addresses the environmental impacts of the design.	N/A	1	2	3	4	5
Addresses economic, social and political constraints on the project.	N/A	1	2	3	4	5
Develops realistic design project schedule which includes all important tasks.	N/A	1	2	3	4	5
Develops a cost estimate (project budget) to do the design engineering.	N/A	1	2	3	4	5

Comments

E3

Drexel University

Freshman Design Project

Faculty Review - Oral Presentation

The purpose of this assessment is to afford faculty and their students an opportunity to review and evaluate the acquisition and demonstration of specific knowledge and skills. This review will take place at the conclusion of the *Oral Presentation* phase of the Freshman Design Project. The faculty member's assessment will be recorded on this review form. A copy of the completed evaluation will be given to the student team as additional feedback on their performance.

Please provide the following information:

			Special Comments:
Course Section			
Term/ Date			
Instructor/ Advisor			
Team ID			
Student Name			
Student Name			
Student Name			
Student Name			
Student Name			

*Generally, all students on the team should receive the same grade unless the instructor/advisor is aware of circumstances that indicate a student has earned a higher or lower grade than his/her team mates. Note rationale under special comments above.

Throughout this phase of the project, the team demonstrated the following CORE knowledge, skills, and abilities:	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
Analytical Skills *Applies logic in solving problems and analyzes problems from different points of view. Translates academic theory into practical applications using appropriate technical techniques, processes, and tools.*	1	2	3	4	5
Communication Skills *Articulates ideas in a clear and concise fashion and uses facts to reinforce points. Written materials flow logically and are grammatically correct. Plans and delivers oral presentations effectively. Uses technology and graphics to support ideas and decisions.*	1	2	3	4	5
Creative Problem-solving *Suggests new approaches and challenges the way things are normally done. Develops many potential solutions to problems while discouraging others from rushing to premature conclusions.*	1	2	3	4	5
Life-Long Learning *Learns independently and continuously seeks to acquire new knowledge. Exceeds basic requirements of an assignment and brings in relevant outside experiences to provide advanced solutions to the problems at hand..*	1	2	3	4	5
Project Management *Sets goals, prioritizes tasks and meets project milestones. Seeks clarification of task requirements and takes corrective action based upon feedback from others. Creates action plans and timetables to complete assigned work.*	1	2	3	4	5
Research Skills *Uses computer based and other resources effectively thus acquiring information from multiple sources. Organizes and interprets data appropriately. Designs and conducts experiments to validate theories.*	1	2	3	4	5
Systems Thinking *Understands how events interrelate and demonstrates an ability to take new information and integrate it with past knowledge. Integrates and uses knowledge from various courses, including Engineering, Physics, Mathematics, and Social Sciences, to solve technical problems.*	1	2	3	4	5
Teamwork *Each member contributes a fair share to the completion of the project. Everyone participates, listens and cooperates with other members. Members share information and help reconcile differences of opinions when they occur.*	1	2	3	4	5

Technical Competencies

Throughout this phase of the project, the team demonstrated the following TECHNICAL knowledge, skills, and abilities:	Not Applicable	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5

Comments

E4

Drexel University

Freshman Design Project

Faculty Review - Final Report

The purpose of this assessment is to afford faculty and their students an opportunity to review and evaluate the acquisition and demonstration of specific knowledge and skills. This review will take place at the conclusion of the *Final Report* phase of the Freshman Design Project. The faculty member's assessment will be recorded on this review form. A copy of the completed evaluation will be given to the student team as additional feedback on their performance.

Please provide the following information:

			Special Comments:
Course Section			
Term/ Date			
Instructor/ Advisor			
Team ID			
Student Name			
Student Name			
Student Name			
Student Name			
Student Name			

*Generally, all students on the team should receive the same grade unless the instructor/advisor is aware of circumstances that indicate a student has earned a higher or lower grade than his/her team mates. Note rationale under special comments above.

Throughout this phase of the project, the team demonstrated the following CORE knowledge, skills, and abilities:	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
Analytical Skills *Applies logic in solving problems and analyzes problems from different points of view. Translates academic theory into practical applications using appropriate technical techniques, processes, and tools.*	1	2	3	4	5
Communication Skills *Articulates ideas in a clear and concise fashion and uses facts to reinforce points. Written materials flow logically and are grammatically correct. Plans and delivers oral presentations effectively. Uses technology and graphics to support ideas and decisions.*	1	2	3	4	5
Creative Problem-solving *Suggests new approaches and challenges the way things are normally done. Develops many potential solutions to problems while discouraging others from rushing to premature conclusions.*	1	2	3	4	5
Life-Long Learning *Learns independently and continuously seeks to acquire new knowledge. Exceeds basic requirements of an assignment and brings in relevant outside experiences to provide advanced solutions to the problems at hand..*	1	2	3	4	5
Project Management *Sets goals, prioritizes tasks and meets project milestones. Seeks clarification of task requirements and takes corrective action based upon feedback from others. Creates action plans and timetables to complete assigned work.*	1	2	3	4	5
Research Skills *Uses computer based and other resources effectively thus acquiring information from multiple sources. Organizes and interprets data appropriately. Designs and conducts experiments to validate theories.*	1	2	3	4	5
Systems Thinking *Understands how events interrelate and demonstrates an ability to take new information and integrate it with past knowledge. Integrates and uses knowledge from various courses, including Engineering, Physics, Mathematics, and Social Sciences, to solve technical problems.*	1	2	3	4	5
Teamwork *Each member contributes a fair share to the completion of the project. Everyone participates, listens and cooperates with other members. Members share information and help reconcile differences of opinions when they occur.*	1	2	3	4	5

Technical Competencies

Throughout this phase of the project, the team demonstrated the following TECHNICAL knowledge, skills, and abilities:	Not Applicable	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
Applies mathematics to the analysis of final design.	N/A	1	2	3	4	5
Applies knowledge of science (physics, biology, and/or chemistry) to the analysis of final design.	N/A	1	2	3	4	5
Uses rational, objective reasoning (common sense) to arrive at final design among alternatives.	N/A	1	2	3	4	5
Substantiates performance of final design and its elements in an objective manner and does not make unsubstantiated claims. If appropriate, discusses failures and possible remedies	N/A	1	2	3	4	5
Includes the citation of at least eight information sources in research, 4 of which are from print sources.	N/A	1	2	3	4	5
Assesses and addresses the environmental impacts of the final design in a realistic manner.	N/A	1	2	3	4	5
Assesses and addresses economic, social and political impact of the final design.	N/A	1	2	3	4	5
Develops a realistic cost estimate to implement the design.	N/A	1	2	3	4	5
Addresses questions and issues raised during the oral presentation.	N/A	1	2	3	4	5
Suggests ways to extend and improve design.	N/A	1	2	3	4	5

Comments

Drexel University

H1

Freshman Design Project

Faculty Review - Problem Definition

The purpose of this assessment is to afford faculty and their students an opportunity to review and evaluate the acquisition and demonstration of specific knowledge and skills. This review will take place at the conclusion of the *Problem Definition* phase of the Freshman Design Project. The faculty member's assessment will be recorded on this review form. A copy of the completed evaluation will be given to the student team as additional feedback on their performance.

Please provide the following information:

			Special Comments:
Course Section			
Term/ Date			
Instructor/ Advisor			
Team ID			
Student Name			
Student Name			
Student Name			
Student Name			
Student Name			

*Generally, all students on the team should receive the same grade unless the instructor/advisor is aware of circumstances that indicate a student has earned a higher or lower grade than his/her team mates. Note rationale under special comments above.

Throughout this phase of the project, the team demonstrated the following CORE knowledge, skills, and abilities:	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
Analytical Skills *Applies logic in solving problems and analyzes problems from different points of view. Translates academic theory into practical applications using appropriate technical techniques, processes, and tools.*	1	2	3	4	5
Communication Skills *Articulates ideas in a clear and concise fashion and uses facts to reinforce points. Written materials flow logically and are grammatically correct. Plans and delivers oral presentations effectively. Uses technology and graphics to support ideas and decisions.*	1	2	3	4	5
Creative Problem-solving *Suggests new approaches and challenges the way things are normally done. Develops many potential solutions to problems while discouraging others from rushing to premature conclusions.*	1	2	3	4	5
Life-Long Learning *Learns independently and continuously seeks to acquire new knowledge. Exceeds basic requirements of an assignment and brings in relevant outside experiences to provide advanced solutions to the problems at hand..*	1	2	3	4	5
Project Management *Sets goals, prioritizes tasks and meets project milestones. Seeks clarification of task requirements and takes corrective action based upon feedback from others. Creates action plans and timetables to complete assigned work.*	1	2	3	4	5
Research Skills *Uses computer based and other resources effectively thus acquiring information from multiple sources. Organizes and interprets data appropriately. Designs and conducts experiments to validate theories.*	1	2	3	4	5
Systems Thinking *Understands how events interrelate and demonstrates an ability to take new information and integrate it with past knowledge. Integrates and uses knowledge from various courses, including Engineering, Physics, Mathematics, and Social Sciences, to solve technical problems.*	1	2	3	4	5
Teamwork *Each member contributes a fair share to the completion of the project. Everyone participates, listens and cooperates with other members. Members share information and help reconcile differences of opinion when they occur.*	1	2	3	4	5

Technical Competencies

Throughout this phase of the project, the team demonstrated the following TECHNICAL knowledge, skills, and abilities:	Not Applicable	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
Discusses the need for the proposed design in an objective and realistic manner. Presents research that demonstrates need for the proposed design.	N/A	1	2	3	4	5
Identifies and evaluates what, if anything, currently satisfies the need addressed by the proposed design.	N/A	1	2	3	4	5
Presents a coherent argument for the selected project.	N/A	1	2	3	4	5
Identifies constraints/limitations which may be encountered on project.	N/A	1	2	3	4	5
Projects ways of evaluating effectiveness of final design.	N/A	1	2	3	4	5
Demonstrates an understanding of the audience.	N/A	1	2	3	4	5

Comments

Drexel University

H2

Freshman Design Project

Faculty Review - Proposal

The purpose of this assessment is to afford faculty and their students an opportunity to review and evaluate the acquisition and demonstration of specific knowledge and skills. This review will take place at the conclusion of the *Proposal* phase of the Freshman Design Project. The faculty member's assessment will be recorded on this review form. A copy of the completed evaluation will be given to the student team as additional feedback on their performance.

Please provide the following information:

			Special Comments:
Course Section			
Term/ Date			
Instructor/ Advisor			
Team ID			
Student Name			
Student Name			
Student Name			
Student Name			
Student Name			

*Generally, all students on the team should receive the same grade unless the instructor/advisor is aware of circumstances that indicate a student has earned a higher or lower grade than his/her team mates. Note rationale under special comments above.

Throughout this phase of the project, the team demonstrated the following CORE knowledge, skills, and abilities:	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
Analytical Skills *Applies logic in solving problems and analyzes problems from different points of view. Translates academic theory into practical applications using appropriate technical techniques, processes, and tools.*	1	2	3	4	5
Communication Skills *Articulates ideas in a clear and concise fashion and uses facts to reinforce points. Written materials flow logically and are grammatically correct. Plans and delivers oral presentations effectively. Uses technology and graphics to support ideas and decisions.*	1	2	3	4	5
Creative Problem-solving *Suggests new approaches and challenges the way things are normally done. Develops many potential solutions to problems while discouraging others from rushing to premature conclusions.*	1	2	3	4	5
Life-Long Learning *Learns independently and continuously seeks to acquire new knowledge. Exceeds basic requirements of an assignment and brings in relevant outside experiences to provide advanced solutions to the problems at hand..*	1	2	3	4	5
Project Management *Sets goals, prioritizes tasks and meets project milestones. Seeks clarification of task requirements and takes corrective action based upon feedback from others. Creates action plans and timetables to complete assigned work.*	1	2	3	4	5
Research Skills *Uses computer based and other resources effectively thus acquiring information from multiple sources. Organizes and interprets data appropriately. Designs and conducts experiments to validate theories.*	1	2	3	4	5
Systems Thinking *Understands how events interrelate and demonstrates an ability to take new information and integrate it with past knowledge. Integrates and uses knowledge from various courses, including Engineering, Physics, Mathematics, and Social Sciences, to solve technical problems.*	1	2	3	4	5
Teamwork *Each member contributes a fair share to the completion of the project. Everyone participates, listens and cooperates with other members. Members share information and help reconcile differences of opinions when they occur.*	1	2	3	4	5

Technical Competencies

Throughout this phase of the project, the team demonstrated the following TECHNICAL knowledge, skills, and abilities:	Not Applicable	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
Identifies and evaluates at least two design alternatives.	N/A	1	2	3	4	5
Presents a coherent argument for the chosen solution.	N/A	1	2	3	4	5
Details testing and evaluating procedures.	N/A	1	2	3	4	5
Includes the citation of at least four information sources in research.	N/A	1	2	3	4	5
Identifies additional information/data needs.	N/A	1	2	3	4	5
Addresses the environmental impacts of the design.	N/A	1	2	3	4	5
Addresses economic, social and political constraints on the project.	N/A	1	2	3	4	5
Develops realistic design project schedule which includes all important tasks.	N/A	1	2	3	4	5
Demonstrates an understanding of the audience.	N/A	1	2	3	4	5

Comments

H3

Drexel University

Freshman Design Project

Faculty Review - Oral Presentation

The purpose of this assessment is to afford faculty and their students an opportunity to review and evaluate the acquisition and demonstration of specific knowledge and skills. This review will take place at the conclusion of the *Oral Presentation* phase of the Freshman Design Project. The faculty member's assessment will be recorded on this review form. A copy of the completed evaluation will be given to the student team as additional feedback on their performance.

Please provide the following information:

Course Section		
Term/ Date		
Instructor/ Advisor		
Team ID		
Student Name		
Student Name		
Student Name		
Student Name		
Student Name		

Special Comments:

*Generally, all students on the team should receive the same grade unless the instructor/advisor is aware of circumstances that indicate a student has earned a higher or lower grade than his/her team mates. Note rationale under special comments above.

Throughout this phase of the project, the team demonstrated the following CORE knowledge, skills, and abilities:	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
Analytical Skills *Applies logic in solving problems and analyzes problems from different points of view. Translates academic theory into practical applications using appropriate technical techniques, processes, and tools.*	1	2	3	4	5
Communication Skills *Articulates ideas in a clear and concise fashion and uses facts to reinforce points. Written materials flow logically and are grammatically correct. Plans and delivers oral presentations effectively. Uses technology and graphics to support ideas and decisions.*	1	2	3	4	5
Creative Problem-solving *Suggests new approaches and challenges the way things are normally done. Develops many potential solutions to problems while discouraging others from rushing to premature conclusions.*	1	2	3	4	5
Life-Long Learning *Learns independently and continuously seeks to acquire new knowledge. Exceeds basic requirements of an assignment and brings in relevant outside experiences to provide advanced solutions to the problems at hand..*	1	2	3	4	5
Project Management *Sets goals, prioritizes tasks and meets project milestones. Seeks clarification of task requirements and takes corrective action based upon feedback from others. Creates action plans and timetables to complete assigned work.*	1	2	3	4	5
Research Skills *Uses computer based and other resources effectively thus acquiring information from multiple sources. Organizes and interprets data appropriately. Designs and conducts experiments to validate theories.*	1	2	3	4	5
Systems Thinking *Understands how events interrelate and demonstrates an ability to take new information and integrate it with past knowledge. Integrates and uses knowledge from various courses, including Engineering, Physics, Mathematics, and Social Sciences, to solve technical problems.*	1	2	3	4	5
Teamwork *Each member contributes a fair share to the completion of the project. Everyone participates, listens and cooperates with other members. Members share information and help reconcile differences of opinions when they occur.*	1	2	3	4	5

Faculty Review

Technical Competencies

Throughout this phase of the project, the team demonstrated the following TECHNICAL knowledge, skills, and abilities:	Not Applicable	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5
To be determined by Faculty	N/A	1	2	3	4	5

Comments

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H4	# Drexel University
	## Freshman Design Project
	## Faculty Review - Final Report

The purpose of this assessment is to afford faculty and their students an opportunity to review and evaluate the acquisition and demonstration of specific knowledge and skills. This review will take place at the conclusion of the *Final Report* phase of the Freshman Design Project. The faculty member's assessment will be recorded on this review form. A copy of the completed evaluation will be given to the student team as additional feedback on their performance.

Please provide the following information:

			Special Comments:
Course Section			
Term/ Date			
Instructor/ Advisor			
Team ID			
Student Name			
Student Name			
Student Name			
Student Name			
Student Name			

*Generally, all students on the team should receive the same grade unless the instructor/advisor is aware of circumstances that indicate a student has earned a higher or lower grade than his/her team mates. Note rationale under special comments above.

Throughout this phase of the project, the team demonstrated the following CORE knowledge, skills, and abilities:	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
Analytical Skills *Applies logic in solving problems and analyzes problems from different points of view. Translates academic theory into practical applications using appropriate technical techniques, processes, and tools.*	1	2	3	4	5
Communication Skills *Articulates ideas in a clear and concise fashion and uses facts to reinforce points. Written materials flow logically and are grammatically correct. Plans and delivers oral presentations effectively. Uses technology and graphics to support ideas and decisions.*	1	2	3	4	5
Creative Problem-solving *Suggests new approaches and challenges the way things are normally done. Develops many potential solutions to problems while discouraging others from rushing to premature conclusions.*	1	2	3	4	5
Life-Long Learning *Learns independently and continuously seeks to acquire new knowledge. Exceeds basic requirements of an assignment and brings in relevant outside experiences to provide advanced solutions to the problems at hand..*	1	2	3	4	5
Project Management *Sets goals, prioritizes tasks and meets project milestones. Seeks clarification of task requirements and takes corrective action based upon feedback from others. Creates action plans and timetables to complete assigned work.*	1	2	3	4	5
Research Skills *Uses computer based and other resources effectively thus acquiring information from multiple sources. Organizes and interprets data appropriately. Designs and conducts experiments to validate theories.*	1	2	3	4	5
Systems Thinking *Understands how events interrelate and demonstrates an ability to take new information and integrate it with past knowledge. Integrates and uses knowledge from various courses, including Engineering, Physics, Mathematics, and Social Sciences, to solve technical problems.*	1	2	3	4	5
Teamwork *Each member contributes a fair share to the completion of the project. Everyone participates, listens and cooperates with other members. Members share information and help reconcile differences of opinions when they occur.*	1	2	3	4	5

Technical Competencies

Throughout this phase of the project, the team demonstrated the following TECHNICAL knowledge, skills, and abilities:	Not Applicable	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
Identifies alternatives and justifies choice of final design.	N/A	1	2	3	4	5
Substantiates performance of final design and its elements in an objective manner and does not make unsubstantiated claims. If appropriate, discusses failures and possible remedies	N/A	1	2	3	4	5
Includes the citation of at least eight information sources in research, 4 of which are from print sources.	N/A	1	2	3	4	5
Assesses and addresses the environmental impacts of the final design in a realistic manner.	N/A	1	2	3	4	5
Assesses and addresses economic, social and political impact of the final design.	N/A	1	2	3	4	5
Addresses questions and issues raised during the oral presentation.	N/A	1	2	3	4	5
Demonstrates an understanding of audience.	N/A	1	2	3	4	5
Presents final design in an organized and coherent fashion.	N/A	1	2	3	4	5

Comments

Drexel University

Freshman Design Project
Student Review

The purpose of this student review is to afford students an opportunity to review and evaluate the acquisition and demonstration of specific knowledge and skills throughout the course specified above. This review will take place at the conclusion of the course. Please take the time required to complete this course evaluation thoughtfully. A copy of the completed evaluation will be given to the instructor as additional feedback on the course for purposes of future improvement of the course.

Please provide the following information:

Course Section	
Semester/ Date	
Instructor/ Advisor	

Special Comments:

During this course I was provided with the opportunity to learn and practice the following CORE skills:	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
Analytical Skills *Apply logic in solving problems and analyze problems from different points of views. Translate academic theory into practical applications using appropriate technical techniques, processes, and tools.*	1	2	3	4	5
Communication Skills *Articulate ideas in a clear and concise fashion and use facts to reinforce points. Plan and deliver oral written presentations effectively. Use technology and graphics to support ideas and decisions.*	1	2	3	4	5
Creative Problem-solving *Generate new ideas and develop many potential solutions to problems. Suggest new approaches to solving technical problems and challenge the way things are normally done.*	1	2	3	4	5
Life-Long Learning *Learn independently and continuously seek to acquire new knowledge. Bring in relevant outside experiences to provide advanced solutions to the problems at hand..*	1	2	3	4	5
Project Management *Set goals, prioritize tasks and meet project milestones. Seek clarification of task requirements and take corrective action based upon feedback from others. Create action plans and timetables to complete assigned work.*	1	2	3	4	5
Research Skills *Use computer based resources effectively thus acquiring information from multiple sources and organize and interpret data appropriately. Design and conduct experiments to validate hypotheses and theories.*	1	2	3	4	5
Systems Thinking *Understand how events interrelate and demonstrate an ability to take new information and integrate it with past knowledge. Integrate and use knowledge from various courses, including Engineering, Physics, Mathematics, and Social Sciences, to solve technical problems.*	1	2	3	4	5
Teamwork *Encourage participation among all team members. Listen and cooperate with other members. Share information and help reconcile differences of opinions when they occur.*	1	2	3	4	5

During this course I was provided with the opportunity to learn and practice the following TECHNICAL skills:	Not at All	To a Limited Extent	To a Moderat e Extent	To a Great Extent	To a Very Great Extent
Technical Competencies customized by faculty.	1	2	3	4	5
Technical Competencies customized by faculty.	1	2	3	4	5
Technical Competencies customized by faculty.	1	2	3	4	5
Technical Competencies customized by faculty.	1	2	3	4	5
Technical Competencies customized by faculty.	1	2	3	4	5

Please answer the following questions about this course.

	Not at all	Infrequently (1 or 2Xs)	Average Frequency (4-5Xs)	Very Frequently (6-8Xs)	Every Class
How frequently did your instructor use technology to deliver instruction in the course or lab?	Not at all	Infrequently (1 or 2Xs)	Average Frequency (4-5Xs)	Very Frequently (6-8Xs)	Every Class
How effective was this technology used to support your acquisition and development of the above **CORE** and **TECHNICAL** competencies.	Not at all	Somewhat Effective	Moderately Effective	Highly Effective	
How frequently did you work in teams or groups in your course?	Not at all	Infrequently (1 or 3Xs)	Average Frequency (4-6Xs)	Very Frequently (6-9Xs)	Every Class
To what extent was this engineering course integrated with at least one other discipline or different kind of subject matter (cross-disciplinary exercises, projects, tests, lab activities, etc.).	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent
To what extent did you receive feedback on your acquisition and development of the **CORE** and **TECHNICAL** competencies during the course?	Not at all	Infrequently (1 or 3Xs during course)	Average Frequency (4-6Xs during course)	Very Frequently (6-9Xs during course)	Every Class
Overall, how satisfied are you with the teaching/learning process in this course?	Not at All	To a Limited Extent	To a Moderate Extent	To a Great Extent	To a Very Great Extent

		Extent	Extent		

Freshman Design Project   Student Review

Please answer the following questions about this course. Use the back of the page if you need more space for your comments.

Give three specific examples on how this course helped you to acquire and develop the **CORE** competencies listed above?

_____

_____

_____

_____

_____

Give three specific examples on how this course helped you to acquire and develop the **TECHNICAL** competencies listed above?

_____

_____

_____

_____

_____

Please list three ways in which you would improve this course to help you acquire and develop the **CORE** and **TECHNICAL** competencies listed above?

_____

_____

_____

_____

_____

Describe an example of the types of feedback you received from your instructor(s) beyond traditional grades to help you acquire and develop the **CORE** and **TECHNICAL** competencies listed above.