Section 3461

IMPROVING ENGINEERING STUDENTS' WRITING THROUGH COLLABORATION BETWEEN WRITING CENTERS AND ENGINEERING FACULTY

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Introduction

Engineering Graphics 166 (EG166) is required of all beginning engineering students at The Ohio State University. The course has always focused on graphical communications. In it, students learn how to make 3-D sketches that would allow a non-technical audience to understand their ideas for new equipment or products, detailed drawings that could be sent to a machinist who would fabricate the object, graphs of all types for presenting and analyzing data, and computer-generated drawings. However, in recent years, the scope of EG166 has been broadened to include written and oral communications as well. The change first occurred in response to a 1992 survey of 1000 graduates of The Ohio State University College of Engineering.[1,2] In this survey, graduates who had been on the job for one to five years were asked to indicate the importance of several skills in the categories of basic engineering, graphics, computer use, and communications. The skills receiving the highest "importance rating" from these practicing engineers were written and oral communications. More recently the Accreditation Board for Engineering and Technology (ABET) has released a new set of accrediting criteria for engineering programs in the United States, requiring engineering programs to demonstrate that their graduates have " an ability to communicate effectively." The emphasis on communications in EG166 was increased by including a team design project in thecourse. The project ran in parallel with instruction in graphics for the last six weeks of the quarter. Students were required to design a piece of equipment to solve a simple engineering problem, prepare a complete set of working drawings for the equipment, produce a written report, and make an oral presentation on their work.

Meanwhile, in the English Department, faculty and graduate students in the University Writing Center had recognized that writing styles and conventions, and indeed the purpose of writing, varied from one discipline to another. In an effort to make their services more valuable to students throughout the University, Writing Center staff members contacted faculty from many different departments and conducted in-depth interviews with them to learn about the writing requirements and instruction in those departments. During an interview with an Engineering Graphics faculty member, staff from the University Writing Center learned about the written reports required in EG166.

University Writing Center staff believed that the EG166 design project report was a vehicle they could use to learn about writing in engineering, and the Engineering Graphics faculty welcomed comments and suggestions from the Writing Center that could help them improve the quality of the engineering students' writing. Plans were made for collaboration during the 1996-97 school year. During that same year, The Ohio State University, a member of the NSF-sponsored Gateway Engineering Education Coalition, was participating in a project to encourage the improvement of writing instruction in Engineering. Funding from that Gateway project allowed the University Writing Center staff and Engineering Graphics faculty to spend more time assessing the writing in EG166 than might otherwise have been possible.

This paper describes what writing was required in EG166, how it was taught, the methods University Writing Center staff used to assess the writing instruction in EG166, their findings, and a handbook the Writing Center staff produced for use in the EG166 course. The handbook was used for the first time in EG166 Autumn Quarter 1997, and some observations on the student response to the handbook and its effectiveness are presented.

EG166 Writing Assignment and Instruction

During the last six weeks of EG166, students are divided into teams and given a design problem. Examples of design problems are: (1) Design a device that will provide a dog with fresh water for two weeks while the owner is on vacation. (2) Design a wagon that a child, age 2-5, could play with inside. The wagon should be safe, attractive, and educational. (3) Design a computer desk for a dorm room. The desk should have storage space for all of the necessary supplies, and it needs to be compact.

Each team is asked to identify at least four alternative solutions to the problem, select one final design, prepare a full set of working drawings, write a complete project report, and give an oral presentation to the class on their project. Students are to work on this project in parallel with their continuing instruction on engineering graphics. As a result, there is little time for formal instruction on writing and oral presentations. When the project is introduced, one class period (48 minutes) is spent on explaining the design process and discussing the outline of the project report. Since the report outline closely follows the design process, discussion of the design process helps the students understand what information is to be conveyed in each section of the report. The first five steps in the design process presented to the students in this beginning course are:

1. Problem statement
2. Requirements and constraints
3. Preliminary concepts
4. Analysis and refinement of preliminary concepts
5. Final design and documentation (i.e., description and drawings of the final design).

Design normally includes development of a prototype, testing, and iteration until a marketable product is ready, but in the limited time available, beginning students are only asked to do and write about the first five steps. The written report has five chapters, one corresponding to each step in the design process. A more detailed outline of the report is in Appendix A.

Two weeks after the project is introduced, each 4-student team submits a draft of the first three chapters of its report. The Engineering Graphics instructor grades the drafts commenting on the writing and format as well as the engineering content. The marked draft is returned to the students in two to four days, and a few minutes of class time might be devoted to discussion of common errors. In the fourth week of the project, students submit a draft of the last two chapters, minus the drawings. That draft is graded and returned in less than a week. At that time, the instructor has a short (10-minute) discussion of oral presentations, including requirements for this particular assignment and some general tips for making effective presentations. Teams submit their final reports on the last day of class.

Having the students prepare drafts was designed to serve two purposes. First, by revising a draft that has been carefully marked, students have an opportunity to correct their mistakes and prepare a final report that closely resembles one that they might have to produce on the job. By contrast, students who turn in a report for the first time at the end of the quarter rarely see the comments made on the reports, and virtually never have an opportunity to correct them. As a result, many students have learned only how to write a poor design report. The second advantage of having the students submit drafts is that the instructor can address each team's problems directly without taking the large amount of class time necessary to discuss all of the possible errors.

Writing Center Assessment of Writing Instruction in EG166

Since EG166 is taught every quarter, staff members from the University Writing Center had an opportunity to work with an Engineering Graphics instructor throughout the year. During the first quarter, Writing Center personnel observed the EG166 class. They video taped the presentation on the design process and report format and commented on points that were not clearly presented. They read the instructor's comments on the drafts and observed the class when drafts were returned. Throughout the quarter, they met with the instructor to provide comments and feedback on instruction methods, comments on the drafts, and student reactions they observed while in the class.

During the second quarter, in addition to observing the class and reading comments, the Writing Center personnel compared the final reports with the marked drafts to see how students used the instructor's comments when revising the report. The types of comments the instructor made on drafts were cataloged, and the efficacy of each type was analyzed based on the changes students made in the final report. It was becoming clear that engineering students tended to make changes exactly as the instructor had marked them. Writing Center staff thought that since students were so willing to follow

suggestions, perhaps a handbook that gave students a more detailed description of the content of each chapter and examples of the format to be used would lead to better first drafts. They began work on a handbook to be tested the next quarter.

In the third quarter, a draft handbook was given to the students when they began to write the design project report. Writing Center personnel also added in-depth student interviews to their assessment program. They randomly selected three teams and met with them four times: after the initial presentation of the design process and report format, when the two drafts were returned, and when the final report was submitted at the end of the course. During the interviews, they asked students to comment on the effectiveness of the in-class instruction on writing, the handbook, the instructor's suggestions on the drafts, and how the students had used those suggestions when preparing their final report. The Engineering Graphics instructor was not present during the interviews, and students seemed to speak freely.

Writing Center staff categorized the Engineering Graphics instructor's comments on the drafts as:

1. Editing (changing the words for students)
2. Directive (telling the writer what to do - often related to format)
3. Directive with information (telling the writer what to do and why)
4. Informational/explanatory without guidance
5. Informational/explanatory with guidance
6. Questions.

The staff members then checked the final report to see which comments had been followed. Generally, the editing, and directive comments were followed exactly. However, if the problem that had been pointed out in a comment occurred other places in the report and was not noted by the instructor, the student only corrected the error in the one place it was marked. Informational/explanatory comments and questions generally led to correction of a problem each place it occurred - unless the student didn't understand the instructor's question or explanation. In the latter cases, the students usually made no changes at all. In student interviews conducted by the Writing Center staff, students indicated that they simply hadn't considered asking the Engineering Graphics instructor for clarification of comments on their writing, even though the Engineering Graphics instructor had written the comments.

Students taking EG166 in the third quarter of the study were given a first draft of the handbook that described the report format in some detail and identified common errors that students should avoid in their writing. The handbook seemed to help. Draft reports contained fewer formatting and structural errors. A Writing Center staff member who had worked on this study and the Engineering Graphics instructor worked together during the summer of 1997 to revise the handbook so it could be used in all Engineering Graphics courses beginning Autumn Quarter 1997.

Student Response to the Design Report Handbook

The Engineering Graphics courses at The Ohio State University are constantly being revised and updated, and the summer of 1997 was no exception. As part of that revision, the team design project was moved to the second Engineering Graphics course (EG167) so that the students would have time to develop more engineering skills to apply to the design project. However, an individual design project was kept in the EG166 course, and students were to prepare a report on that project. The detailed design report handbook was incorporated into the EG167 instructional materials and would be used beginning in 1998. A streamlined version of the handbook was included in the instructional materials for EG166 and was used when students wrote their individual design reports in Autumn Quarter 1997.

Time allowed for the students to complete the individual design project in EG166 was so short that it was not possible for the instructor to provide comments on a draft report prior to the students' submitting the final document. Yet, twenty-five of the thirty students in the class submitted reports with the desired content and in a format that made it easy for the reader to find the information he or she wanted. In the previous year, when two drafts of the report were required and the Engineering Graphics instructor commented on them extensively, the reports were not as well-organized as the ones done by students whose only guidance was the very short handbook.

Discussion

Very early in the collaboration between the University Writing Center (staffed with faculty and graduate students from the English Department) and the Engineering Graphics faculty member, the Writing Center staff observed that engineering students seemed quite willing to produce the work that was required of them. When students were given comments on their draft reports, they generally incorporated those comments verbatim. When Writing Center staff interviewed students and asked them how they responded to comments written on their reports, the students almost always said "I made the changes the instructor suggested." The only exceptions to that response seemed to be when the students didn't understand the instructor's comments.

It appears that getting students to prepare acceptable project reports primarily requires that the instructors make clear what is "acceptable." Certainly, engineering faculty try to make their instructions clear, but since many of them have written numerous reports, they may leave out important information that they take for granted but which is totally unfamiliar to students.

Members of the Writing Center staff observing the Engineering Graphics course, reviewing the instructor's comments on reports, and studying the students' responses to those comments were able to identify the areas where the instructor had not given the students clear guidance. For example, early in the report the students are to list the requirements for the product to be designed and the constraints placed on the designer.

After the students develop several preliminary concepts, they are to analyze those concepts in light of the requirements and constraints to identify the best concept. Students had great difficulty with the "Analysis" section of the report because the relationship between the requirements/constraints and the analysis was not explained to them. The instructor took that relationship for granted and did not mention it, but the Writing Center staff immediately identified the reason for the students' confusion.

Writing Center personnel were also able to help the Engineering Graphics instructor understand the differences between the type of writing that was being required in a design report and the writing that is generally required in the freshman composition courses. When the engineering instructor understands those differences he or she can point them out to the student, thus reducing confusion about the assignment. One major difference identified was that in composition courses, students are to assume that the reader is going to start with the first line and read the entire document while engineering reports are written assuming that a reader is often interested in one specific piece of information and will go directly to the section where it is to be found. Thus the design report needs a table of contents, headings, subheadings, and occasional repetition of critical information so that a person turning to the middle of a report can understand the context in which the information is being presented.

The collaboration between the University Writing Center and the engineering faculty described in this paper has led to a clearer guidance on writing assignments in the Engineering Graphics courses, which has, in turn, led to better written reports. The handbook, whose short version is presented in Appendix A, seems to be particularly helpful to students. The format and writing style outlined in the handbook will not be appropriate for many other engineering courses requiring written reports. However, a similar document may well prove to be useful.

Acknowledgment

This project of the Gateway Engineering Education Coalition, (NSF Award EEC-9444246), is supported in part by the Engineering Education and Centers Division of the National Science Foundation.

References

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2. Fentiman, A.W., R.R. Britton, F.D. Meyers, "The First Two Years: Are Engineering Students Learning the Skills They Need?, Engineering Design Graphics Journal, Vol. 58, No. 2, pp. 30-37, 1994.

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APPENDIX A

HANDBOOK FOR DESIGN PROJECT REPORTS IN ENGINEERING GRAPHICS COURSES

Each Engineering Graphics student will do an individual design project and prepare a report on that project. This handbook is designed to help students prepare a high-quality, professional report. It contains a general outline of the report, a description of the contents of each section of the report, and some tips on writing style and presentation of the material that will give the report a more professional appearance.

1. REPORT OUTLINE

This section of the handbook contains an outline of the report on the design project.

Cover Page

Table of Contents

List of Figures

I. Introduction
   - A. Statement of the problem
   - B. Why solving the problem is important
   - C. Organization of the report

II. Requirements, Constraints, and Information Needs
   - A. Introduction to the section
   - B. Requirements
   - C. Constraints
   - D. Information needs

III. Preliminary Concepts
   - A. Introduction to the section
   - B. Concept One - description and illustration
   - C. Concept Two - description and illustration
   - D. Concept Three - description and illustration
   - E. Concept Four - description and illustration

IV. Analysis
    A. Introduction to the section
    B. Advantages and disadvantages of each preliminary concept in light of the requirements and constraints
    C. Data gathered to satisfy the information needs
    D. Selection of the final design
        i. Justification of the selection based on requirements and constraints
        ii. Refinements made and reasons for them

V. Final Design
    A. Introduction to the section
    B. Description of the final design
    C. Working drawings
        i. Assembly drawing
        ii. Bill of material
        iii. Detail drawings

2. DESCRIPTION OF SECTION CONTENTS

This section of the handbook provides some information on what should be included in each part of the report, along with some hints or examples that might be helpful in preparing that part of the report. Each part of the report is covered in a separate subsection of the handbook.

Cover Page

Must Include:

- Project title
- Student's name
- Course name and number
- DATE!!!

Hints:

1. Be sure that each time a draft or revision of the report is turned in, the date is changed on the cover page.
2. Use a design or logo on the cover page.
3. Look at the title page of a book or cover of a report for an example of a cover page.

Table of Contents

Must Include:

- Number of each part or chapter
- Part or chapter titles
- Page on which each chapter begins

Hints:

1. The page number for the Table of Contents is "i".
2. If a chapter is several pages long, in the Table of Contents, give only the number of the first page of the chapter.
3. Look in some published reports or books for examples.

List of Figures

Must Include:

- Figure number
- Figure title (as it appears in the caption on the figure)
- Page on which the figure is found

Hints:

1. Assuming that the Table of Contents is only one page long, the List of Figures is on page "ii".
2. Look in published reports or books for examples.

Introduction

This part of the report has three main purposes. First, it tells the reader exactly what problem is being solved or what piece (or pieces) of equipment will be designed. Next, it explains to the reader why this work is important. Finally, the last paragraph of the introduction gives the reader a "road map" to the report by describing the organization of the report. For example, the last paragraph might contain sentences such as, "Chapter 2 contains the requirements and constraints the design must meet." or "Descriptions and illustrations of four preliminary designs are presented in Chapter 3."

NOTE: Very few people read a report from cover to cover. They scan the introduction to see whether the project being described is of interest to them. If it is of interest, they

might check the "Organization of the Report" to see which section will provide the information they are seeking.

Requirements, Constraints, and Information Needs

How does the sponsor, i.e., the person who paid for the project, decide whether the design is acceptable? He or she makes that decision by determining whether the product meets all of the requirements and can be produced within the constraints.

This section describes the requirements and constraints that will be used to judge the design. In it, the student also identifies any additional information he or she will need to gather in order to design an acceptable product. An example of a requirement, a constraint, and an information need follow.

Suppose a student is to design a child's car seat that converts into a stroller. A **requirement** might be that the seat be light enough for one person to lift easily. However, a **constraint**, at least here in Ohio, is the law that any child weighing 45 pounds or less must be in a car seat while traveling in an automobile. The car seat must, therefore, be strong enough to support a 45-pound child, and that certainly could affect the weight of the car seat. As a result, two **information needs** might be the density and strength of a variety of materials that could be used in a car seat.

Preliminary Concepts

The reader will turn to this part of the report to learn about the preliminary ideas. Some readers will learn more by reading a written description of each concept, some will prefer an illustration, and still others will use both. Thus the author must provide a clear written description of each concept, an illustration of each concept, and a link between the text and the illustration.

Hints:

1. Give each concept a descriptive name so the reader can remember it easily.
2. Think of the written description of each concept as what a designer might say in a telephone conversation with a potential customer who has asked for a description of the product. The goal is to paint a "mental picture" of the concept.
3. Each concept should be described with about the same level of detail.
4. Stick to the facts. This is not an advertisement. It is a formal, professional report.
5. Include an illustration of each concept.
6. Refer to the illustration in the text so that the reader knows the illustration is available. Here are some examples of references to an illustration: "The three-wheeled stroller, shown in Figure 3.5, is ..." or "One unique feature of this concept is the detachable canopy. (See Figure 3.7.)"

7. Illustrations should follow the paragraph in which they are first mentioned, if the illustrations occupy less than a full page. If an illustration requires a full page, it should be on the page following the one in which it is first mentioned.
8. Each illustration (figure) should have a number and a title. For example:
   Figure 3.5. Three-Wheeled Stroller/Car Seat Combination in Stroller Mode.

Analysis

In this part, the student reports on his or her evaluation of the four preliminary concepts, in light of the requirements and constraints, and on the selection of a final design. The reader should be able to follow the student's reasoning as he or she accepts or rejects all or parts of each concept and selects a final design. In addition, the student will describe any refinements to the design and the reasons for them.

Final Design

If the reader turns to this chapter first, he or she should find a written description of the final design that provides a clear "mental picture" of the design. That description should be followed by a set of working drawings which includes an assembly drawing, a bill of material, and detail drawings. If this set of drawings were taken to a machine shop, the machinist should be able to build the item as designed.

Hints:

1. At the end of the description, be sure to tell the reader that the working drawings follow.
2. The name and number on each detail drawing should correspond to the name and number of the part on the assembly drawing.
3. Check the detail drawings to be sure that the fit between two mating parts is the desired fit, i.e. be sure that the dimensions and tolerances are correct.

3. TIPS

Some tips on report preparation could apply to more than one part of the report. Those tips are presented in this section of the handbook. A special subsection contains tips on figures.

1. The report is a formal, professional document. It is not advertising copy. Use formal language. Choose words carefully. Be accurate. Do not exaggerate.
2. Provide as much detail as is necessary to describe the project but be as concise as possible. Be considerate of the reader. Don't waste his or her time. If a word doesn't provide new or important information, leave it out.

3. Use 1 ½ or double spacing.
4. Number the pages. The Table of Contents is on page "i", the List of Figures is on page "ii", and the first chapter "Introduction" begins on page 1.
5. Use headings and subheadings to help the reader follow the organization of the report or find the section of interest. Chapter titles should be the same as those in the Table on Contents. If a numbering system is used for headings and subheadings, it should be the same as the one in the Table of Contents.
6. Every chapter, with the exception of the introductory chapter, should begin with an introduction that tells the reader what is contained in that chapter. Remember, the reader may have turned to this chapter without reading earlier parts of the report.

Tips on Figures

Few students have experience putting figures in reports. But in technical reports, figures are often very important. The reader must be able to locate the figure and quickly understand how it is related to the text. Here are some tips on figures.

1. A figure should have a number and a descriptive title. Some examples follow.
    - Figure 1. Multiview drawing of the three-wheeled stroller concept.
    - Figure 7. Graph showing densities of various stroller construction materials.
2. The figure number and title in the List of Figures should be the same as the number and title in the body of the report.
3. Each figure should be described and referenced in the text so that the reader knows to look for the illustration.
4. A figure should follow the paragraph in which it is first mentioned, if the figure is small, or follow the page on which it is first mentioned, if the figure requires an entire page.
5. Horizontal figures should be put in the report so that the top of the drawing is on the left and the bottom is on the right. Be careful that the margins are wide enough that the entire figure, including its title, is visible when the report is bound.