Instructional Modules for Teaching Written, Oral, and Graphical Communication Skills to Engineering Students

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Abstract

EC 2000 requires that engineering students learn and demonstrate an ability to communicate effectively, which in an engineering environment implies oral, written, and graphical communication skills. The already overcrowded curriculum and pedagogical considerations makes adding communications courses unacceptable. We prepared three short instructional modules suitable for teaching these skills in any engineering course as a part of a more extensive program to develop instructional modules in several EC 2000 skill areas. Each module uses three 50-minute classes and relies on active-cooperative learning strategies and Internet-based resources. Instructional material includes PowerPoint slides, in-class team activities, homework assignments, and an instructor guide. We have tested each module in an evaluation program where a faculty member who did not develop the module taught it to approximately ten students. These data showed improvement in the students' confidence in their ability to complete tasks identified in the module's learning objectives. They also indicated that the learning objectives were clear and supported by the material, that the justifications were clear and convincing, that the lecture material, team activities, and assignments were appropriate.

Introduction

EC 2000 requires that engineering students learn and demonstrate an ability to communicate effectively, implying that they develop oral, written, and graphical communication skills in an engineering context[1]. The already overcrowded curriculum makes adding communications courses unacceptable. Also, from a pedagogical point of view, teaching these skills as a part of a standard engineering course makes them more meaningful to the student than teaching them in stand-alone courses. However, most engineering faculty members have little experience in teaching these topics and will need user-friendly instructional material to implement this approach. In response to this need, we prepared three short instructional modules suitable for teaching these skills in any engineering course as a part of a more extensive program to develop instructional modules in several EC 2000 skill areas. Interested instructors may access these three modules and others dealing with additional topics at ece.ua.edu/faculty/rpimmel/public_html/ec2000-modules.

Instructional Module Organization

Each of the three modules uses three 50-minute classes and relies heavily on active-cooperative learning strategies and Internet-based resources. Instructional material includes PowerPoint slides for each class along with in-class team activities and homework assignments. An instructor's guide, also a part of the module material, discusses the use of the other material and approaches for grading student work.

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In each session, we alternate cooperative learning exercises with short mini-lectures describing some established ideas on the topic. This approach provides some instruction in the skill, followed by a chance to practice it, followed by a chance to see and evaluate other students' efforts and to have their work evaluated both by students and the instructor, all important steps in learning a skill [2, 3]. Ideally the instructor would then give an assignment later in the semester on the standard course material that involved the skill (e. g., give a formal presentation summarizing the results of an extended design project). Besides providing another opportunity to practice the skill, this later assignment extends the skill into an engineering context making it much more relevant to the students[4].

Learning Objectives

Restricting the modules to three classes forced us to select a subset of material for each of the three modules. Table 1 shows the topics for each session for the modules.

Session	Oral Communications	Written Communications	Graphical Communications
1	**Strategies for effective presentations**	**Key components in executive summaries**	**Graphing data and interpreting graphs**
2	**Student presentations**	**Process for writing executive summaries**	**Sketching diagrams**
3	**Student presentations**	**Identifying well written executive summaries**	**Data and figures in reports**

Table 1. *Topics for each session in the three modules.*

We focus the oral communications module on strategies for making oral presentations. We expect that after completing the module, students should be able to:

(1) Write guidelines for effective presentation

(2) Plan, prepare, and deliver a presentation

(3) Critique a presentation (provided evaluation received adequate class time and emphasis)

The first session provides instruction on strategies for making an effective presentation and, if the instructor chooses to spend the time, on approaches for evaluating presentations. At the end of this session, the instructor assigns teams of students to prepare talks on some aspect of presentations. They prepare these talks using references, normally found on various web sites, and deliver them in the second and third session.

We focus the written communications module on executive summaries as a representative form of technical writing. We design the material so that, after completing the module, the students should be able to:

(1) Distinguish between well-written and poorly-written executive summaries

(2) Identify the attributes of a well-written executive summary

(3) Write an effective executive summary on a topic in the course where the module is offered

The written communications module requires no specific prerequisite knowledge. However, it is best if students have successfully completed a fundamental English composition course. In the first session students are introduced to the key components of an executive summary, and at the end of the period they should be able to list and describe these key components. The objective of the second session is to have the students develop a process that they can use to write an executive summary. In the third session students learn to identify well-written abstracts and executive summaries, and are provided constructive feedback and ideas to assist them in improving their writing.

We focus the graphical communications module on the types of figures that would be included in a technical report, as well as the types of sketches that are needed to support engineering calculations. After completing the module, the students should be able to:

(1) Plot data correctly on paper or the computer

(2) Draw simple sketches including free body diagrams, circuit diagrams, system diagrams, and process diagrams

(3) Use figures correctly when writing a report

(4) Interpret graphical data

(5) Read schematic drawings

The module is designed so that the instructor can pick and choose topics that are most important and relevant for the students in the course without losing continuity. Some of the assignments make use of spreadsheets, such as Excel, and the module assumes that the students have had previous spreadsheet exposure. The first session provides rules for graphing and interpreting linear and non-linear data. The second day continues with plotting logarithmic experimental data and then moves on to sketching the types of diagrams needed for engineering calculations. The third class period is used to discuss how data and figures should be presented in technical reports. Communication using schematic diagrams is discussed, and primary references for standard symbols used in several different disciplines are provided.

Team Exercise

In the introductory material in the first session of the oral communication module, the presentation process is subdivided into three phases: planning, preparing, and delivering. The material contains a few slides on strategies for dealing with each of these phases. The section on preparing presentations contains additional material on preparing good Power Point slides. This session contains two team exercises, each taking about ten minutes of class time. The first asks the students to prepare a set of guidelines for effective presentation while the second asks for a set of Power Point slides. These team exercises actively involve the students and get them thinking about the characteristics of good presentations and slides, making them more receptive to the material presented by the instructor. Announcing ahead of time that a few randomly selected teams will have to report their results encourages all students to take these exercises seriously. Also, the material includes a brief discussion of teaming strategies just before the first team exercise in order to remind the students of some of these ideas.

The written communications module contains team exercises in each of the three sessions. To give an indication of the types of exercises that are included, consider the second session. Session two is comprised of several short periods. In the first segment of the session, students are asked to critique each other's executive summaries written for homework after session one. This exercise allows for the

students to (1) see alternative ways of attacking the problem they were assigned as homework, and (2) receive some feedback from their peers. It is vital that students put forth effort to make their feedback meaningful and constructive. In the second segment of the session students are asked to develop a process by which they can write an executive summary. The in-class, team exercise is for them to do just that. It is important to note that they typically go into this exercise totally confused. Thus, the instructor generally has to "get them started" by spotting them something like "clearly identify your audience" or "start by writing the objective of the paper." However, when students work hard at this exercise, the rest of the module is far more meaningful to them. To properly motivate the students, the assignment is submitted for a grade.

In the first session of the graphical communications module, students work in teams to develop an understanding of the importance of this topic to an engineer. They develop a definition of graphical communication and reasons for its significance. These team exercises are followed by mini-lectures with discussion on the importance of graphical communication. In the first session, they are also given sample graphs containing errors in labeling, units, and other problems commonly made by undergraduate students. The purpose of these incorrect graphs is to allow students to recognize how difficult it can be to interpret a graph that is not formatted correctly. Then they are more willing to listen to the follow-up lecture on "10 Rules for Graphing". The second day involves the actual plotting of some simple graphs. It is recommended that in-class exercises on this day be done as individuals so that everyone has practice putting pencil to paper. In the third session, students work in teams as they answer questions about figures and schematic diagrams that are presented to them.

Homework Assignments

The oral communication module contains two types of homework assignments. The first type were simple exercises that encourages the students to think about the importance of good presentation skills and to consider, organize and prioritize the factors that lead to effective preventions. Sample questions were *"List two reasons why engineers need to develop good presentation skills."* and *"Prepare a single list of the five most important guidelines for planning, preparing, and delivering a talk. Write a sentence or two justifying your choices."* The second type of assignment directs the students to web sites or printed material and requires them, normally as members of a team, to prepare a short talk on some topic dealing with presentation skills (e. g., common mistakes in delivering, preparing for questions, preparing for a hostile audience, or dealing with nervousness).

In the written communications module students are given a pre-assignment to write an executive summary on an assigned topic before coming to the first session. At the end of the first session, students refine their executive summaries based on information presented in the session. After the second session, students are assigned a new topic and are required to produce an executive summary by implementing the process they developed in the session. Finally, students are given a technical report and required to produce the executive summary.

The assignments in the graphical communication module allow students to gain experience in plotting data in Excel. In the final assignment, they are given a large table of data to plot in Excel and then insert into a short Word document. Upperclassmen often have difficulty in putting data into reports due to trying to manipulate the large data files. Tips for doing this are included in the third class period, and this homework assignment gives students the opportunity to practice what they have learned.

Instructor's Guides

The instructor's guide for each of the modules follows a similar format and discusses several issues

that are important to an instructor using this material. The major sections provide tips on:

- Using the instructional material,
- Homework assignments,
- Grading student work,
- Assessment.

Evaluation Procedures

We have tested each module in an evaluation program. In order to see how the material stood on its own, they were taught by a faculty member who did not develop the material, while the module developer and a third faculty member observed the class. The instructor and the observer both completed evaluation forms and made suggestions to the developer for improving the material.

The modules were taught to approximately ten students during a standard 50-minute period on a Monday, Wednesday, and Friday schedule. Students receiving the instruction, referred to as the "experimental group", competed several evaluation forms prior to the start of the module and at the end of the module. In addition, we collected data from a second group of students who were involved in a module on a completely different topic and served as a "control group. Both groups were randomly selected from a larger group of paid volunteers after screening for schedule conflicts. The overall group contained 65 % seniors, 25 % juniors, and 10 % sophomores; 45 % had a GPA above 3.0 while 55 % had one between 2.0 and 3.0; and 61 % had one or more coop or intern experiences, while 39 % had none.

One survey form asked the students to assess their confidence in their ability to complete tasks representative of the module's learning objectives and to indicate their confidence using a five-valued scale (i. e., 1 - *"Strongly Disagree"* … 5 - *"Strongly Agree"*). In creating this list of tasks, we converted each objective into one and only one statement so that there was a one-to-one correspondence between the modules' learning objectives and students' confidence statements. For example, the objective, *"Students should be able to write guidelines for an effective presentation"* became *"I am confident that I can write guidelines for an effective presentation."* We collected post-module and control data with all three modules, but we collected pre-module data only with the written and graphical communication modules. We averaged the selected values for each task and we will refer to this average as a "confidence score". We then averaged the confidence scores for all tasks in a module to obtain an "average confidence score" for each module.

In a second survey, we asked the students to indicate their agreement with a set of statements describing the appropriateness, effectiveness and completeness of the material. For example, we asked them to indicate their agreement with *"The learning objectives were clear"* and *"The instructional material supported the learning objectives."* Figure 5 (which is discussed later) contains a complete list of these questions in a slightly abbreviated form. Again we used a five valued scale (i. e., 1 - *"Strongly Disagree"* … 5 - *"Strongly Agree"*). We averaged the selected values for each statement, and we will refer to this average as the "agreement score". The survey form also provided opportunities for written comments on the appropriateness, effectiveness and completeness of the material.

Results

Figure 1, 2, and 3 show the confidence scores for each task in each of the three modules. In general, the post-module confidence scores are higher than the pre-module and the control values suggesting some improvement in the students' confidence in their ability to perform tasks derived from the modules' learning objectives.

The data in Figure 1 shows that in the oral communications module the average confidence score were higher in the post-module group than in the control group (we did not obtain a pre-module survey in this module). The task *"Evaluate and critique an oral presentation"* showed the largest difference -- 0.7 which means that on the average70 % of the students selected a higher value in the post–module group than in the control group. Two other tasks showed a difference of 0.4 (implying that 40 % of the students selecting a higher value); these dealt with delivering and planning a presentation.

A comparison of the pre-module and post-module data for the written communication module (Figure 2) indicates a fairly substantial increase in the students' confidence to do all three tasks as a result of the instruction in the module. The task on identifying attributes of a well-written summary increased by 0.9 while the task on writing a summary increased by 0.6; these differences imply that 90 % and 60 %, respectively, of the students selected a higher value after the module. Differences between the post-module and control confidence scores were inconsistent showing a positive difference for one task and a negative difference for the other two. Similar difference exist between the control and pre-module data implying a difference in the experimental and control groups, making it hard to identify any effects of the module by group comparisons.

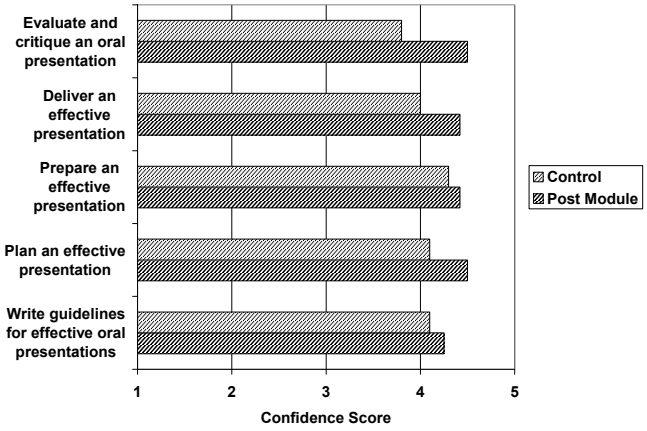

Figure 1. *Confidence scores for tasks based on each objective in oral communication module*

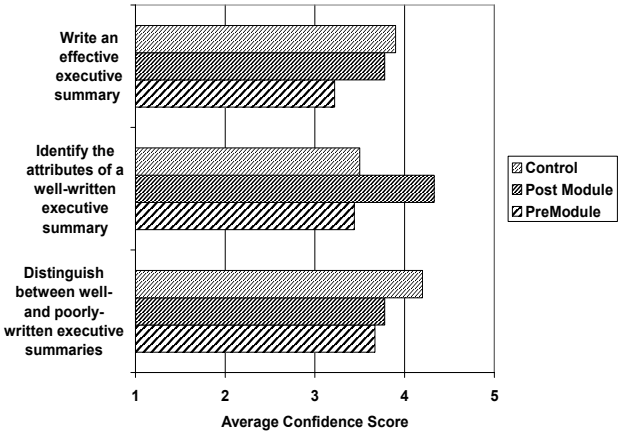

Figure 2. *Confidence scores for tasks based on each objective in written communication module*

Figure 3, the confidence scores for the graphical communication module, show smaller differences than seen with the other two modules. We attribute this lack of effect to the high "baseline" values (i. e., the pre-module and control values), which averaged about 4.4 in both cases. These high values implied that, even before the instruction in the module, 40 % of the students *"Strongly Agreed "* that they could perform the task while 60 % *"Agreed"*, leaving little room for improvement. In spite of this, the confidence scores did improve in four of the five tasks in the experimental group, and they were higher in the post-module data than in the control data.

Figure 4 shows the average confidence scores for the three modules. These data summarize the observation made in the previous three paragraphs discussing the three modules individually. In the oral and written communication modules, these averages show differences between post-module and both pre-module and control averages implying that the module instruction had a positive effect on the students' confidence to perform oral and written communications tasks. For the graphical communication module, the data show the high baseline values (pre-module and control data) and little difference post module. Again these data represent changes in student confidence to do specific tasks; clearly, a process that actually tests their ability to do these tasks would be more convincing, and we plan to conduct such a test in the future.

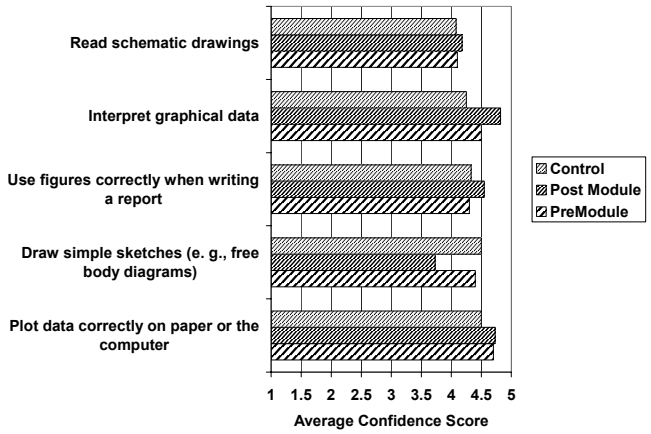

Figure 3. *Confidence scores for tasks based on each objective in graphical communication module*

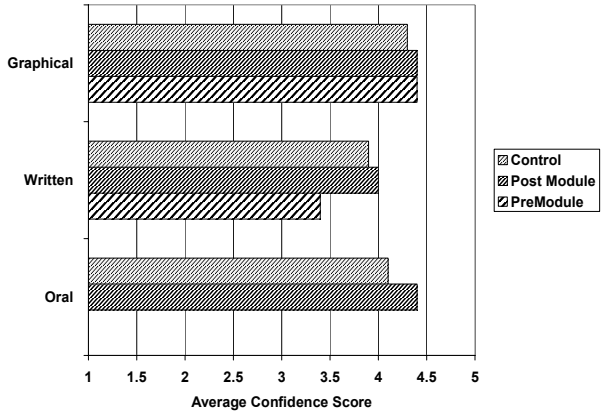

Figure 4. *Average confidence scores for tasks based on objectives in oral, written, and graphical communication modules*

Figure 5 shows the agreement scores with various statements about the appropriateness, effectiveness and completeness of the instructional material. In general, these data indicate that the learning objectives were clear and supported by the instructional material, that the justifications were clear and convincing, that the lecture material, team activities, and assignments were appropriate, as indicated by agreement scores usually greater than 4.0 – the value associated with the descriptor "Agree". The students did give lower scores to statements about the completeness and appropriateness of the material and to the statement about the readiness for release. The averages across the three modules for these three statements were 3.5, 3.7, and 3.3, respectively.

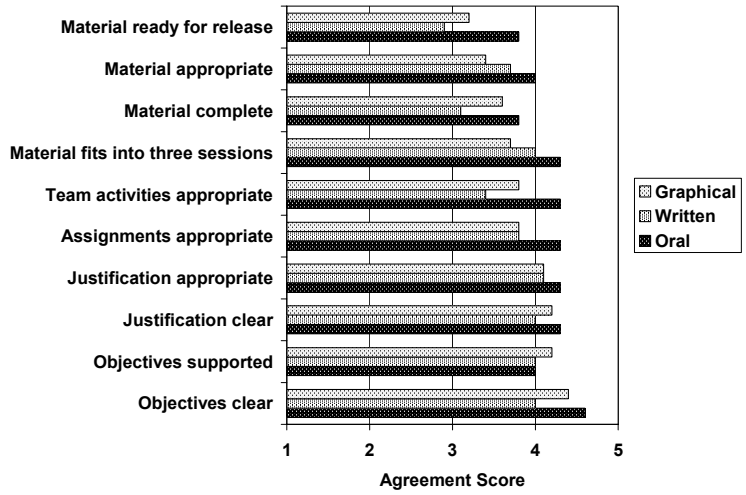

Figure 5. *Agreement scores in student evaluation of oral, written, and graphical communication modules*

A review of the students' written comments in the oral communication module survey pointed out two areas for improvement: the peer evaluation process should have more structure perhaps using a standard form and the material should emphasize the "qualities of good communication" and "methods for effective presentation" rather than general presentation skills. There were several comments on the repetition of the student presentations, but this resulted from the module instructor

allowing the students to pick their presentation topic from the list in the assignment rather than assigning each group a specific topic.

A review of the written comments in the written communication module survey indicated that the in-class activities should be expanded. For instance, it would be desirable to have students present their critiques of each others work on a screen using projection equipment. Then, it would be desirable to have the professor "critique the critique." This was actually the plan for the exercise, but limitations on classroom equipment prevented this when the module was taught.

Conclusion

Based on the evaluations and feedback, both from the students and the faculty instructor and observer, we revised the instructional material. Again, interested instructors may access these modules at ece.ua.edu/faculty/rpimmel/public_html/ec2000-modules. We encourage faculty members at other institutions to consider using these materials and to participate in a more extensive evaluation if they actually choose to use them.

Although the evaluations involved a small number of students and may be considered preliminary, the data suggest that the instructional material in our modules provided some improvement in the students' confidence of their ability to perform certain oral, written, and graphical communication tasks. Since the modules use only three classes, they have a minimal effect on the amount of traditional engineering material that must be deleted from a course when adding instruction in these skills. Module instructors, who were not involved in the development of the material, reported that they typically spent less than one hour preparing for each session. Thus, these modules offer an effective, efficient approach for providing instruction on these communication skills which, with the appearance of EC 2000, have become an important component in an engineering curriculum.

Acknowledgements

This work was supported by the Engineering Education Program of the National Science Foundation under Award Number EEC-9802942.

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