Laboratory Assignments In Writing-Across-the-Curriculum

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Introduction

In a previous article (Zimmerman, 1991), several articles were cited from past issues of the NACTA Journal which had documented the importance and need of well developed communication skills to the success of college graduates (Schaefer, 1984; Broder and Houston, 1986; Cobia, 1986; Coorts, 1987; Riesenberg, 1988). And more recently, Barkley (1991), in a survey of graduates, reported that over 97% of those responding found communication skills to be important in their current positions and concluded that "teaching programs could be strengthened by increasing the communication content of specific courses and the overall curricula".

In the same article (Zimmerman 1991), the "writing-across-the-curriculum" program was also discussed and several NACTA Journal articles were cited in which instructors had described the application of various writing-across-the-curriculum concepts and techniques in science and technical courses to improve the communication skills of graduates (Cobia, 1986; Gamon, 1988; Smith, Poling, and Von Tilburg, 1989; Tudor, 1989; Koch and Houston, 1989). The article specifically addressed the use of journals and journal writing in technical courses in writing-across-the-curriculum.

Laboratory writing assignments in science and technical courses represent yet another excellent opportunity for helping to improve students' communication and thinking skills in writing-across-the-curriculum. This article discusses various types of laboratory format/writing requirement combinations for laboratory instruction and the use of laboratory notebooks and reports in two technical physics courses.

Laboratory Writing Requirements

Laboratories are universally regarded as an essential part of science and technology classes in many disciplines, and rightly so. In the laboratory, students can explore concepts and principles previously covered in the classroom in a "hands-on", application-oriented setting. Laboratory activities also provide students with the opportunity to use visual and kinesthetic as well as auditory methods of learning. Therefore, laboratories not only serve as a review and reinforcement of material presented in the classroom, they enable students to use a wider variety of learning methods.

Laboratory writing requirements generally reflect the particular format used in the laboratory instruction. Although a wide range and variety of approaches to laboratory instruction exist, three of the most common laboratory format/writing assignment combinations may be labeled as "rigidly structured format/fill-in writing requirement" (Type I), "structured format/report writing requirement" (Type II), and "student directed format/notebook and report writing requirement" (Type III).

In the traditional Type I approach (sometimes referred to as the "cookbook method"), students use a laboratory manual or handouts which have completely packaged laboratory exercises. The laboratory guides typically include an introduction; a list of materials and equipment; a detailed step-by-step procedure; printed and labeled data sheets, graphs, and diagrams for recording specific observations; and question and answer worksheets. A biology laboratory manual by Mader (1991) provides a typical example. Students in this type of laboratory work at individual self-contained stations following a "canned" format. Grading is usually based on fill-in answers to questions printed on observation forms and worksheets.

The Type I approach has several advantages. Since students work in a highly structured environment, laboratory planning and operation can be simplified, uniform objectives can be established, specific outcomes can be monitored, and grading can be standardized. The instructor is also assured that all students have completed identical laboratory assignments. Since students are carefully guided through the laboratory exercises, more complex and detailed material and laboratory activities can be covered in the time allotted. Also, large numbers of students can be accommodated, and the uniform answer sheets can be graded quickly and objectively.

Two major disadvantages of the Type I approach to laboratory instruction are: 1) students are not required to use higher levels of cognition or take individual initiative or responsibility for any portion of the laboratory activity, and 2) students do only limited writing and are not given the opportunity to develop and improve technical communication skills.

In the Type II approach to laboratory instruction, a laboratory manual or handouts are provided but are limited to an introduction, a list of materials and equipment, and a step-by-step procedure (sometimes with a data sheet included). Individual self-contained stations and a "canned" format are still used. However, students are required to conceive and construct data tables and graphs, to analyze and discuss results, and to write a formal laboratory report. The report is usually graded based on both technical content and report writing techniques. Brillhart and Debs (1981), Rosenthal (1987), and Gratz (1990), in articles offering suggestions and techniques for teaching laboratory report writing, pro-

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vided examples of the Type II approach to laboratory instruction.

In advocating the Type II approach, Harris (1980, p.v) stated in his applied physics laboratory manual that a proper laboratory guide "will point the way for the student and assist him or her in understanding the principles and in attacking the problem, but the responsibility for thinking through the problem should be placed on the student" and that the emphasis should be on "an original written report of each laboratory investigation". Harris (1980, p.vii) also wrote that "Success in the professions or in management depends on the ability to explain to others the events, processes, plans, and problems which are dealt with day to day. Writing laboratory reports is the best possible training for such responsibilities."

The Type II approach to laboratory instruction partly addresses the major disadvantages of the Type I method and retains some of the advantages. As such, it is a compromise between Type I and the Type III approach described below.

In the Type III approach, students 1) actively participate by planning, setting up, conducting, and following-up laboratory exercises with only limited assistance from the instructor, 2) keep and write in a laboratory notebook, and 3) use the information recorded in the laboratory notebook to prepare formal laboratory reports. This approach to laboratory instruction is modeled after the format and written communications actually used by industry and academia in R & D, design, testing, and pilot plant laboratories and facilities. When incorporated as the basis for laboratory instruction, the Type III approach enables students to gain experience in the procedures actually used in the "real world".

The Type III approach requires that students understand and actively apply principles and concepts before, during, and after the laboratory activity. It also helps them learn and develop skills in notetaking and technical communications. As Kanare (1985, p.2) stated, good laboratory notekeeping "is an acquired skill that can be of tremendous benefit in any career." Kanare (1985, p.121) observed "good communication skills are important in every job and notewriting is a fundamental personal communication skill."

It is important that students (and instructors) understand the difference between laboratory notebooks and laboratory reports and their correct uses. According to Alvarez (1980), a laboratory notebook is a complete record written at the time of occurrence, whereas a laboratory report contains information gathered from the notebook and which is selected and organized based on a particular purpose and audience.

Writing Assigned in Technical Courses

In 1988, the Type III approach was implemented in laboratory instruction in a two course sequence in technical physics which the author teaches at The Ohio State University, Agricultural Technical Institute, a two-year technical college. Several adjustments and refinements have been made during subsequent years. The current techniques and procedures are as described below.

The two technical physics courses include the standard subject areas of mechanics, heat, light, sound, and electricity which are traditional for such offerings. The physics courses (four credit hours each) are taught on the quarter system (ten weeks of classes plus finals week) and meet for four hours of lecture/discussion/problem solving and a two hour laboratory per week. Topics for laboratory exercises are selected and scheduled to parallel subject matter presented in class.

The technical physics courses are required for all students who major in the Engineering Technologies Division (Fluid Power, Construction, Manufacturing, or Power Equipment programs). Depending on their mathematics level at the time of admittance, students will enroll in physics during the latter two quarters of their first year or during the first two quarters of their second year. The physics classes typically have an enrollment of about 12-24 students. Two laboratory sections are scheduled if the enrollment exceeds 12 students.

A laboratory handout (see Appendix) is distributed to and discussed with students during the first class meeting of the quarter. The format used at each laboratory session is as follows: the instructor provides the title for the laboratory activity and briefly reviews with students pertinent aspects of the subject matter previously presented in class; the instructor and students discuss and determine the objectives, materials, equipment, procedures, calculations, data tables, graphs, and expected results for the laboratory exercise; students write in their notebooks during and after this discussion as they prepare for the laboratory activity; students perform the activity and complete their notebooks; and the instructor checks the notebooks.

Generally, about the first 30 minutes of the two hour laboratory period are spent in discussion, notebook preparation, and advance calculations. Likewise, students spend the last part of each laboratory period interpreting the results and writing their discussion and conclusions. Therefore, as a trade-off, scheduled hands-on laboratory activities must be shorter, fewer in number, and less complex than those commonly found in Type I and II approaches. However, students learn the need, value, and importance of planning, preparation, and follow-up when undertaking an activity. Understanding and practicing this comprehensive approach is a valuable experience for students since it is relevant to personal and employment related situations as well as the laboratory.

Emphasis during each laboratory period and throughout the quarter is placed on preparation, understanding, and recording, not on hurrying to complete the activity. In supporting this concept, Kanare (1985, p. 122) wrote that instructors in many college laboratories "often 'reward' students who quickly finish the laboratory sessions by allowing them to leave as soon as the experiments are done; notetaking and writing laboratory reports are postponed until some later time. Such practice reinforces several wrong attitudes, including, 'finishing the work fast is more important than doing the job carefully' and 'writing up the work is a necessary evil, better left for later'."

Materials and equipment required for the laboratory activity are present in the room; however, these items are not prearranged at individual stations. The students are responsible for selecting, assembling, and returning materials and equipment. In conducting laboratory activities, students typically work in groups of two or three, but some activities require that the entire class work together.

Each student is required to keep a notebook. Oral comments and suggestions for improvement concerning the notebooks are made to students during the laboratory period and when the instructor makes a final check at the end of the laboratory session. Laboratory notebooks are collected for overall evaluation and a grade at the end of the quarter. Frequent notebook checks enable the instructor to monitor the students' comprehension of technical subject matter and also to provide constructive feedback concerning the notetaking. Waiting until the end of the quarter to grade the notebook allows students plenty of time to learn correct notetaking. Assigning a grade based on the entire notebook permits the instructor to factor improvements during the quarter into the grade.

The assignment at the completion of each laboratory is for students, either individually or in groups of two or three, to prepare a formal laboratory report based on information contained in their laboratory notebooks. In addition to sections contained in the laboratory notebook, a section entitled either "Information Acquired From Further Study" or "Application to a Specific Area of Technology" is required and is to be based on at least two references. This section allows students to realize and investigate the practical applications of the physics subject matter to their interest and career areas. I have found this to be especially important and valuable in maintaining the interest of students enrolled at a two year technical college. This section also helps students develop and improve their library skills and ability to use resources.

Laboratory reports are due by the next scheduled laboratory period. They are evaluated and, accompanied with brief written comments, are returned to students promptly. Acceptable reports typically range from four to six double-spaced pages. Students have the option of rewriting the reports for an improved grade. Samples of well written reports collected in previous quarters are also made available for students to view. Since eight or nine laboratory reports are required during the quarter, students are provided with considerable feedback regarding correct report writing techniques and do substantial writing. This is very desirable because constructive comments and repeated practice in writing are two of the most important factors in improving writing skills.

The time commitment resulting from increased writing assignments is a genuine and real concern of instructors, especially those with large enrollments in their classes. In the case of the technical physics courses, the time and effort to evaluate and provide feedback concerning the written laboratory assignments has increased since the laboratory notebooks and reports were made a requirement. However, I have found that using such techniques as group discussions of notebooks and reports during class or laboratory, individual discussions with students during the laboratory period or office hours, and concentrating on key items and major errors when reading and evaluating the reports can be important time-saving strategies as well as effective feedback mechanisms.

The laboratory grade represents 30% of the total course grade and is determined based on the eight or nine laboratory reports required each quarter and the laboratory notebook (which counts as the equivalent of one laboratory report). Overall I have been pleased with the efforts and improvements made by most of the students in completing their laboratory writing assignments and the grades that they have achieved. Students can and will work to improve their technical writing skills in science and technology courses in response to the proper guidance and clear standards.

Both the students and I are fortunate in that there is considerable and widespread faculty support of and involvement in writing-across-the-curriculum. Also, the campus has a "Writing Lab" where faculty, tutors, and computers are available to assist students. Obviously students and instructors benefit greatly from such a combined and supportive effort to improve writing and other communication skills.

Conclusion

Requiring students to keep a laboratory notebook helps them develop writing habits, mental discipline, and notetaking skills which are applicable and important in a wide range of learning experiences and employment situations. In addition, the use of notebooks encourages more active participation and critical thinking on the part of students during laboratory activities. Likewise, the requirement to write formal laboratory reports based on information in the laboratory notebook and library references helps develop and reinforce critical thinking and technical communication skills, and independent information seeking and learning capabilities.

Effective writing assignments enhance learning at the higher levels of cognition, emphasize writing as a process, involve the student personally, and provide for frequent constructive feedback. Laboratory notebooks and reports each provide an exceptional opportunity to fulfill these conditions, and can be even more effective if used together. And, as an integral component of many courses, laboratories represent an existing, familiar, and excellent mechanism by which faculty in science and technology can incorporate more writing in their courses in support of writing-across-the-curriculum.

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Appendix

Engineering Technologies Division
Technical Physics Lab Notebook and Reports Handout

Lab Notebook

You are required to keep a handwritten notebook using 5 square engineering paper for recording all pertinent information and observations concerning each lab activity (Note: A looseleaf notebook is specified in this course because of cost and evaluation considerations. A *bound* notebook is used in actual practice). Record your name, the course name, and the date that the course began on the first page. The next page is entitled "Table of Contents". The title of each laboratory session and the page number on which it begins are to be listed on this page.

Record the date, time, and names of any lab partners and number the pages used at each session. The laboratory notebook consists of the following five sections which are entered and *underlined* as headings:

I. Title
II. Introduction & Objectives
III. Materials, Equipment & Procedures
IV. Data, Calculations, & Results
V. Discussion & Conclusions

You, other students and the instructor will discuss and plan the lab activity during the first part of the lab period. You will write in your notebook during and after this discussion as you prepare for the lab activity and as you complete it. The instructor will check the notebook entries during and at the conclusion of the lab period and provide oral comments and suggestions. The lab notebooks will be collected for evaluation at the end of the quarter.

Keeping a good lab notebook requires discipline and practice and should be a matter of habit. Write so that entries are legible, accurate, neat, and clean. Use a pen so that the record is permanent. *Never erase!* Instead, draw a line through unwanted entries. Enter all information directly into the notebook immediately. *Never write information on separate pieces of paper for copying into the notebook later!*

The guiding principle for keeping a lab notebook is to write with enough detail and clarity so that another person with similar subject knowledge can duplicate the activity and make the same observations based on the written notebook entry. Try to be brief, but do not omit any essential information.

Lab Reports

The assignment at the completion of each laboratory is a formal lab report based on information contained in the lab notebook. The reports can be completed individually or in groups of 2-3. The report is to be organized into the same five categories (headings) as listed for the lab notebook. In addition, Section VI., entitled either "Information Obtained by Further Study" or "Application to a Specific Area of Technology" and based on at least two references (other than the class text), is to be included. The references are to be listed in Section VII.

The laboratory reports are to be *typed or machine printed.* Tables, sketches, graphs, and diagrams can be handwritten. Cover sheets, table of contents, and separate reference pages are *not* required. The reports will be graded on quality and quantity of content and on correct report writing techniques such as organization, clarity, grammar, and spelling. Reports are due by the next scheduled lab period. You have the option of rewriting the reports for an improved grade.