

Incorporating Writing in an Integrated Calculus, Linear Algebra and Differential Equations Sequence

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Abstract

In many universities across the country writing is being stressed throughout the curriculum. Faculty see the need to expose students to more writing and to teach the students the correct writing styles for their disciplines. Since 1991 the University of Wisconsin-La Crosse has required students to take a writing intensive course in their major. The Mathematics Department first addressed this requirement by offering various courses as writing intensive; instructors would decide when they wished to teach a course with a writing emphasis. There were various drawbacks to this system, and in 1998 the Department changed its format to a writing intensive sequence. Writing is incorporated throughout a four-semester sequence integrating calculus, linear algebra and differential equations.

In this paper the specific courses in this sequence are described along with how the writing has been implemented in each course. Ideas are also given for how to efficiently handle the additional paper load so students receive the necessary feedback while keeping the grading time reasonable.

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1 Writing Program

Writing-across-the-curriculum has become widely popular in recent years. Universities are recognizing the importance of writing skills for their students. After graduation, students will be expected to communicate both verbally and in writing with a variety of people including perhaps their bosses, colleagues and the general public. For this reason it is important for students to learn the appropriate writing styles and techniques both within and outside their discipline.

¹Key Words: Writing, Calculus, Linear Algebra, Differential Equations, Curriculum

In mathematics students need to learn to incorporate mathematical language and notation with English text. By formally writing out their work, the students also gain a better understanding of the concepts and learn the difference between a final answer and a solution.

To better educate students in writing, the University of Wisconsin-La Crosse instituted a writing requirement as part of its General Education Program; each student must complete two courses designated as writing intensive courses, one of which must be in the student's major. Faculty attend a workshop in which they are introduced to the specific requirements of a

introduction to mathematical writing.

Since we vary instructors for courses in our Department, most of the twenty-three faculty members teach courses in this sequence at some time. To help unify the approach we have to writing, a committee wrote a formal Writing-In-The-Major Proposal [10] that was approved by the Department and the University of Wisconsin-La Crosse's General Education Committee. The proposal included the following points: (1) forms of formal writing students will be expected to learn, such as technical reports, expository papers, and elementary proofs which will be discussed in the following section; (2) an outline of how our program is structured to advance writing skills as students progress through the sequence, as discussed in Section 2; (3) shared criteria for faculty on how to evaluate student writing along with helpful points on managing the additional grading, as discussed in Section 3; (4) a process for assessing the quality of the program, as outlined in Section 4.

2 Writing In the Sequence

The sequence in which we have incorporated writing is a four-semester sequence integrating calculus, linear algebra and some differential equations. One goal for this sequence is to help students see the connections between these areas rather than view them as discrete topics. The topics are mixed through the semesters as described later. This is the entry-level sequence in our mathematics major. Some of the courses are also required for other majors such as chemistry (first three courses) and physics (first three courses for some areas and all four courses for other areas). By requiring this sequence as a prerequisite to most of our upper level mathematics courses, we insure a consistent background in both mathematics and writing for all of our junior and senior level students.

Writing assignments for these courses can come from project books or

appropriate for specific assignments.

Different instructors handle the details of the assignments differently. In some cases students work in teams on the writing assignments. This is one way to cut down on the amount of grading required and still have the students doing some writing. It can also be helpful to the students to discuss the problem with someone. Having two people to proof-read the paper is also a plus. In other cases, usually only on the longer assignments, students first hand in a rough draft on which they receive feedback. A final draft is then due approximately one week after the rough draft is returned. This approach, although more time consuming for the instructor, gives the student the opportunity to apply the feedback they receive. Another version of this approach is to have students first hand in just the mathematical steps in the solution of the problem. This can then be checked for correctness and completeness before the student begins writing up their explanations and conclusions. This approach helps the students to pace their work instead of pushing it all off until shortly before the assignment is due.

Many assignments involve some use of technology. This allows the students to examine more involved problems with more realistic conditions. The technology helps them with messier computations and with more detailed graphs.

Since the writing is taught in a sequence, the expectations increase as the students progress through the courses. The types of assignments are designed to reflect the students' level of development. The specific types of assignments for each course will be explained below.

2.1 Course One

The first course in our sequence is a standard five-credit first-semester calculus course. The topics covered include limits, differentiation and basic integration. In this course we begin the students' introduction to writing in mathematics using homework problems that require students to explain, interpret or analyze their solution to a problem rather than just writing out the mathematical steps. The problems are familiar, but they are asked to describe the solution process in English as well as using mathematical notation. These assignments are typically no more than a page or two in length. They are intended to increase the students' comfort with a particular mathematical idea and get them to begin writing about mathematics for a specific audience. These types of problems can be found in most textbooks, but may also come from project books such as [2] and [6]. In many

equations and sequences and series. With the linear algebra included in this

costs for the materials used for various parts along with welding costs. The students are asked to determine the dimensions of a dumpster of the same volume and general shape which minimizes the cost. They are also asked to describe and justify any simplifications that they used and how these simplifications affected the results. The problem goes on to ask the students if they would want to alter the general shape of the dumpster. This project uses partial derivatives in a more involved extrema problem than those they would have worked on in the first calculus course.

As another possible writing assignment, students could be asked to prove $\sum_{n=1}^6 1/n^2 = 49/36$. This sum was proved by Euler and can be evaluated using double integrals. In working through this proof the students will also

Figure 1: Sample Evaluation Sheet

appropriate for the given audience. The explanations appropriately utilize (without justification) only a certain body of knowledge that the audience is assumed to possess. (6) The paper should be well organized and easy to follow. The outline and style of the paper is consistent with the given style and includes all components specified. The transitions from topic to topic facilitate understanding of major ideas. (7) Basic writing skills including spelling, grammar, and punctuation should be flawless. Graphs, tables, and other referenced information are inserted in, or appended to, the paper appropriately.

Now that we have given ideas for a writing intensive sequence and the shared criteria on which they will be evaluated, you may be wondering how to handle the additional grading. One way to manage the work is to design evaluation sheets (see a sample in Figure 1). This idea combines techniques of instructors at our institution and ideas given by B. Walvoord [8].

For each assignment, an evaluation sheet is written. This sheet would contain a chart listing various items that will be checked in the paper and the number of points each item is worth. This listing includes both mathematical steps and writing quality. Mathematical items could include specific questions asked in the assignment and appropriateness of details given to explain solutions. The writing points could include a proper introduction and conclusion, writing to the appropriate audience and the use of correct

grammar and spelling. Sometimes an instructor may wish to give this sheet to students while they are working on their assignments to help them focus their efforts on the correct areas. Other times it may be more appropriate to only give this to students when their graded papers are being returned.

Below such a chart the instructor lists common comments that they expect they will use when grading the assignments. When grading each paper, the instructor simply circles the comments which pertain to that paper. This part has been particularly useful in saving time by not having to write the same comment over and over. Below these general comments, other specific comments can be added by hand.

In practice, the evaluation sheet appears to have several benefits. The students seemed to take the typed comments more seriously than handwritten ones and later papers show greater improvement. In addition, the students seemed pleased to know exactly how they were graded. This method also saves the instructor a great deal of time in grading by making the process more systematic.

4 Assessment

Since our new approach to writing is only two years old, we have not yet completed a formal assessment of the writing program or the integrated mathematics sequence. The integrated aspect of the core sequence is cur-

aspects of the problem, analyze and solve the problem, and explain their work in a clear manner.

A summary of the results of this review is distributed to the Department. If it is determined that students are not meeting the Department's expectations, the results of the review are used to identify actions the Department might take to address the apparent weaknesses in the students' work. So far these reviews of student work have indicated that the program seems to be working. In the future, we will be looking at the effect of the writing intensive sequence on later courses in the major. Certain upper level courses consistently have students working on projects and writing reports. Instructors of these courses will be asked whether they see an improvement in the students' writing once the students have gone through the writing intensive sequence. At this point the writing program has not been in effect long enough for the students to reach the upper level courses.

5 Conclusion

This paper presents some of the ideas we have used for our writing program. The main point to our program is to give the students several semesters to begin to develop their writing skills. Requiring appropriate writing assignments in many upper level courses then sharpens these skills

We have given ideas of types of writing assignments that could be used and ideas to help with the additional grading. Included in the bibliography are a few references which we have found helpful. As suggested in the paper, we created many of the writing assignments by simply elaborating on ideas given in texts.

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