

# "Using Writing in Calculus to Promote Critical Thinking."

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The "Rule of 4", examining a concept symbolically, numerically, graphically, and verbally, is prominent in reform calculus. As a result, writing is being introduced more and more into math classes as a way to get students to explore an idea verbally. At Virginia Tech several ways we do this are:

- writing in class
- writing using technology
- using newsgroups

**Writing in class:** One of the ways we induce students to write in class is to write a letter to a classmate or to a high school student explaining a concept. "Letters to Laura" or "Letters to Ben" were written to a high school student who was having trouble with calculus or with technology. Some of the letters explained finding the area under a graph; explained the differences between antiderivative, definite integral and indefinite integral; outlined the important topics learned in class at the end of the semester; summarized a chapter; and explained Mathematica commands in order to work with data in homework problems.

We did not grade for grammar, although we noted the corrections on the paper. We told the students that we were only grading for Mathematical correctness and clarity in expressing the idea of the paper. Could a confused high school student understand the problem after he read the paper? Peer evaluation of writing can also be used where the students review each others' papers.

**Writing using technology:** At Virginia Tech we integrate computers into the classes, primarily using Mathematica or Excel. We incorporate writing into the lab problems by asking the students to explain problems or, in the case of projects, answering questions in a cover report. In one of the projects in Math 1206, integral calculus, the students are asked to find the center of mass of a graph. No equations are given. With Mathematica they are to find points on the curve and use Riemann sums to estimate the center of mass. The lab report to be handed in with the Mathematica work asks the students following: Describe the problem. How do you plan to solve the problem? Include the calculations and results including an explanation of the equations and steps used. Make a check on the calculations. This can be a physical model, for instance, a card-board cut-out.

Another example would be to compare the graphs of two functions, one of which is the derivative of the other. The students are asked to determine which function is the derivative and which is the original function and to justify their decision.

Excel is used in our business calculus classes. Data is given in a spreadsheet and students are asked to analyze the data. An example is data that includes revenue, cost, marginal revenue, marginal cost. The students can then construct graphs and charts using Excel. Then they will use their calculus concepts to analyze the data, draw conclusions and make predictions. In this way the students develop good intuition for the differential and integral calculus as applied to business. They are then asked to write a short paper supporting their results and conclusions.

**Using newsgroups:** Several instructors at Virginia Tech are using newsgroups to foster communication about calculus in their classes. At present the students receive extra credit points to use the newsgroups, but will probably be required to participate several times in future classes. Students not only ask questions, but also answer the questions of others.