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# Pumps, Filters, and Lenses; Humanistic Issues in Calculus Reform

Dan Kalman

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Today's slogans describe calculus as a pump or filter. According to this metaphor, mathematics is just a treatment plant for students in the pipeline from high school to technical or professional employment. But I like to think of calculus as a lens through which students may catch a glimpse of the humanistic side of mathematics, and I am confident that many other teachers share this view. With this attitude, it is a natural reaction for us to view the various proposals for calculus reform with alarm. If the syllabus is made more relevant, more accessible, more applicable to the subject areas that have made calculus a requirement, what will become of the liberal arts component of calculus instruction? The advocates of reform have my sympathy when they argue that mathematics departments should get out of the business of filtering students for other disciplines. But this may mean reducing calculus to a course that emphasizes the skills and intuitive understanding needed for applying calculus. Can reform of this type be consistent with the liberal arts goals of education? I intend to argue that the answer is yes, provided we adopt a broader viewpoint: Curriculum reform.

Before making my case, let me discuss the liberal arts component of calculus. An educated member of our society should have an understanding of the historical evolution of the culture, of the forces that shaped it, and that continue to shape it. Without question one of the significant forces has been mathematics. This is not only a reflection of the role that mathematics has played in the development of science and technology. Mathematics has also played a significant role in philosophy.

Calculus offers many opportunities for discussing the impact of mathematics on our culture. On one level, as the foundation for Newtonian mechanics, the contribution of mathematics to classical physics can be made clear. On a second level, calculus provides a stage for exhibiting the epistemological issues that lead from naive Platonism to formalism. We describe the constructs of calculus in intuitive terms, but then present formal definitions. The intuitive descriptions depend on a shared perception of an ideal platonic reality; the formal definitions recognize the need to create an abstract universe for the precise description of that perception. The historical context for the development of the formal definitions is inseparable

from a broader movement in philosophy. The arithmetization of analysis at once provides a microcosm for and exemplifies a contributing force to this philosophical movement. It is appropriate to discuss these issues in calculus courses, both to provide a historical background, and to give a clearer understanding of the methodology and epistemology of mathematics. Thus, to me, the point of including limits in calculus has never been to further the students' understanding of calculus, but rather to further the understanding of calculus, but rather to further the understanding of mathematics.

Calculus can be a vehicle for addressing other aspects of liberal arts instruction, as well. It provides opportunities for exposing students to aesthetic considerations in the formulation and derivation of mathematical knowledge. It is a subject whose development is widely recognized as one of the intellectual triumphs of our culture, and we may attempt to show our students why it is so considered.

As the foregoing makes clear, I have a number of instructional goals for calculus that go far beyond imparting a conceptual and operational mastery of the content. There seems to be little room for these goals in the calculus that is to come. Yet, after an initial negative reaction, I find that I can agree with many of the reform proposals. How can this be? In part, my agreement with the proposals stems from reconsidering whether my goals for instruction are appropriate for the student audience, particularly that segment of the audience conscripted by course work requirements from other disciplines. Additionally, my agreement is contingent upon the adoption of a wider scope for the reform. I can accept the deletion from calculus of liberal arts instructional goals, provided that these goals are provided a suitable platform *somewhere* in the curriculum. These points are elaborated below.

The first point has to do with the fit between instructional goals and student audience. One of the criticisms of the calculus status quo is that we attempt to make every calculus student a mathematician. Indeed, I fear I have been guilty of exploiting the captive audience of calculus students to further my own goals for liberal education. But as a participant in many faculty senate debates on universal requirements for a liberal arts degree, I recognize that

there are more subjects that an educated citizen ought to be comfortable with than can be accommodated in a set of universal requirements for a four year degree. Education must include some selection, and we understand that the true goal is to make the student self educating. Accordingly, I refrain from insisting that every educated citizen must be acquainted with the discipline of mathematics. It would be inconsistent to insist on this same kind of exposure for the subset of students who happen to be required to master the techniques of calculus. They may be right who advise us to focus on the concepts and applications of calculus.

As I said, I don't insist that every undergraduate student be exposed to mathematics in the liberal arts sense. What I do insist is that the universities and colleges provide every student an *opportunity* for this kind of exposure. We have an obligation to offer and to promote courses that will address the issue I have already mentioned: the historical evolution of mathematics, its impact on our culture, a sense of its methodology and epistemology, and the role of aesthetics. We all recognize that college algebra or trigonometry (as usually taught) do not contribute to these goals of liberal education, and we

should not be content to offer these alone to students that lack the background to tackle calculus. Meaningful courses taught by dedicated faculty are needed, not just for the mathematically unsophisticated, but for our majors, as well. These should be courses in which we take pride; courses we are pleased to recommend to our talented majors, and which we use to showcase our discipline to the rest of the academic community. There should be courses of this type that is the logical offering for students who currently enroll in calculus because they desire collegiate mathematics experience and find that calculus is the *next course*. Then, *let* them turn calculus into a skills course. *Let* them offer it in high school for equivalent college credit. And let us get out of the filtering business.

Calculus reform has grown out of a deep discontent with a narrow part of the mathematics curriculum. Heightened awareness of curricular issues and participation in discussion of these issues is one of the results. But we should not address only that part that has become the focus of criticism. Rather, let us take this opportunity to address the curriculum as a whole. The liberal arts component of mathematics instruction can thus be a beneficiary, and not a victim, of calculus reform.