RETHINKING BUSINESS CALCULUS IN THE ERA OF SPREADSHETS

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Abstract: The author is writing an electronic "book" to support the teaching of calculus to business students with the assumption that they will use a spreadsheet as their main computational engine. With the change in technology, it is appropriate to rethink the content of the course, as a different technology makes different tasks accessible. This study looks at what the content of the course should be. It compares the official learning objects of the course, with de facto learning objectives obtained by analyzing final exams from 20 sections of the course, and with the results of a survey of the faculty of the business school, the client discipline. It is intended that this preliminary study will establish a baseline that can be used to evaluate the effectiveness of the new approach to the course.

Key Words: Applied Calculus, Spreadsheets, Technology And Syllabus, Client Discipline Expectations

This report represents an attempt to look at the first issues of the scholarship of teaching and learning that arise in an effort to rethink business calculus. The underlying project looks at reforming a course that is typically a one semester, multiple section, terminal mathematics, service course offered for business students and which is typically taught by adjuncts or teaching assistants. A central premise in the rethinking of the course is that there are pedagogical advantages of teaching a terminal service course using the discipline standard software of the client discipline. For a business calculus class, that would call for using spreadsheets as the main computational engine. From a practical point of view, it is noted that in the last 5 years it has become reasonable to assume that business students will come to college with a laptop computer and office software. However, the teaching staff for business calculus typically has little or no training in business or in software used in a business setting. From a practical point of view, it is unrealistic to assume that schools will devote substantially more material to the course either in credit hours in the curriculum, or in quality of teaching resources. Thus the project assumes the rethought course needs to be teachable by adjuncts and teaching assistants with little training in business.

The rethinking of business calculus with the availability of spreadsheets brings up an interconnected web of issues for the larger project. Changing the technology used in the course changes the topics that are accessible. In particular, it becomes possible to routinely include problems where the students are given data and need to choose a mathematical model and fit the data to the model. Spreadsheets also make it reasonable to address problems of rate of change and accumulation where the underlying function is not continuous. Changing to a spreadsheet should involve a reexamination of conventions used in mathematics classes. In the standard mathematics convention formulas should be compact and use single letter names. This convention aids symbol manipulation. Conventions for spreadsheets emphasize readability, so more descriptive variable names are used and more steps broken down. The use of data defined problems and the development of the programming skills in spreadsheets implies the exchange

of electronic documents rather than allowing evaluation on paper and pencil tests. Since the teaching staff will include adjuncts, the material must address the training of instructors without a background in business. The author envisions the development of the underlying project will provide material for a series of SOTL projects.

In context, the underlying project fits in with calls from the professional organizations. In its report, *The Curriculum Foundations Project: Voices of the Partner Disciplines* (2004), the Curriculum Reform Across the First Two Years (CRAFTY) subcommittee of the Mathematical Association of America (MAA) made a number of suggestions for revisions of lower division mathematics courses aimed at partner disciplines. The report on business and management was the result of a conference at the University of Arizona in 2000. The report made a number of recommendations, including using spreadsheets rather than technology designed for the sciences, written reports with an emphasis on communication skills, and working with problems defined by data rather than formulas so that modeling is given greater emphasis.

In the 12 years since the conference in Arizona, the author is aware of only two projects to rethink the teaching of business calculus by reworking the course with the assumption that students will use spreadsheets as their primary computational tool for the course. The two projects are from Appalachian State University (Felkel and Richardson) and University of Arizona (Lamoureux and Thompson). The author has contacted the authors of both of those projects and in both cases wan told the authors neither made nor is aware of any SOTL studies connected with their projects.

The naïve background research question of the larger project is "Does the daily use of spreadsheets in a business calculus class lead to an increased success of the students in achieving the learning objectives of the course?" The problem with the naïve "What works?" question is that it assumes the objectives of the course are abstractly defined without any consideration of what is possible. At this preliminary stage a more appropriate question looks at what can be and compares it to what already is. The main research question at the center of the preliminary study is: "If Excel is available to students on a daily basis, how should the learning objectives of a one semester course in business calculus be reshaped to better meet the desires and expectations of the faculty of the business school?" The companion question to what can be asks about what is to give context. Thus, the study also looks at he current learning objectives, both those formally stated, and the de facto objectives deduced from looking at old exams.

A review of the literature failed to find any publications directly on point other than the CRAFTY report previously mentioned. There is some literature on the use of Excel in a business calculus class, but it all looks at using Excel as a supplemental tool where the text and syllabus was devised assuming no technology was available. (E.g., Liang and Martin, DuPont.)

For the preliminary study the author conducted a survey of the faculty of the business school. Respondents were asked to rank objectives on a scale from 0, not at all important, to 10, essential. Approximately 30% of the 60 faculty members responded. The survey listed 25 objectives broken into 4 groups. To establish a context, the author also looked at information from 2 other sources. The course has an official set of learning objectives published by the math department. To establish a de facto set of learning objectives the author grouped the official learning objective list into 9 clusters of objectives, then did an analysis of a random sample of 20 of the approximately 50 final exams for the course over the past 5 years to see how possible final exam points were distributed. (Table 1)

Table 1: De facto objectives taken from final exams from 20 sections

Cluster of learning objectives	Percentage of points
Algebra and pre-calculus skills	12.
Limits and continuity	11.4
The limit definition of derivative	3.6
Derivatives and graphs, finding max symbolically	16
Symbolic differentiation and finding tangent lines	22.6
Derivative word problems	10.4
Symbolic integration	16.0
Multivariable functions and partial derivatives	6.4
Miscellaneous	1.6

The results of the survey revealed some methodological problems with the construction of the survey. The author did not anticipate the extent to which the respondents would make differing use of the scale with one respondent marking 21 of 25 objectives as essential, while another respondent marked that none of the objectives were essential. To correct for this use of scale the author looked at which objectives each respondent put in the top and bottom half on in that respondent's ranking of the objectives.

Table 2: Results of faculty survey. Objectives and number of business faculty who ranked each objective as more essential than their mean response.

Math 132 is a calculus course that is typically the last math course taken by CSB students. For such a course, how important would you rank the following in terms of being a major objective of the course?	Times rated above mean (Of 18)
understanding the concepts of calculus	16
skill in proving theorems of calculus	2
skill with the mathematical techniques of calculus	12
skill in mathematical reasoning that comes from calculus	15
For general math course taken by CSB students, how important would you rank the following in terms of being an outcome of the course?	
skill with a graphing calculator	2
skill with using Excel for business problem-solving	13
skill in problem solving	18
skill with modeling data to formulas	18
skill with written presentations	10
skill with making logical arguments	15
skill with manipulating mathematical formulas	14
The proposed shift to Excel in MATH 132 allows some change in emphasis. How important are the following skills for CSB students taking this course?	
applying calculus to examples from business and finance	16
using mathematical reasoning in written presentations	2
working with functions that are only defined for whole number inputs (e.g., the amount of a payment as a function of the number of payments)	12
building and documenting templates that can be used for a type of problem	15

The current MATH 132, like most traditional calculus courses, has a heavy emphasis on symbolic manipulation skills. As we consider adjusting the content of MATH 132, how important are the following calculus skills for CSB students? (These are current student learning objectives of the course.)	
Computing with basic functions: lines, quadratics, etc.	12
Computing with exponential and logarithmic functions.	11
Demonstrate an understanding of limits and continuity.	2
Use the limit definition to compute derivatives.	3
Use differentiation rules to compute derivatives.	7
Use derivatives to sketch graphs of functions.	7
Word problems with derivatives, solve marginal analysis, related rates, and optimization problems.	13
Finding anti-derivatives and indefinite integrals	2
Solving word problems with integration and accumulation.	5
Understanding functions of several variables and computing partial derivatives.	7

The results of the survey showed some marked differences between the desires of the faculty in the client discipline and the de facto objectives determined by points possible on the final exams. A rough summary of the de facto objectives is that the course is modeled after the standard 3-semester calculus sequence designed to prepare for a major in physics, before graphing technology was readily available. To fit the course in a single semester, the emphasis is on symbolic manipulations skills and computational techniques. Virtually no problems required the use of any technology or the fitting of data to a mathematical model. Symbolic integration was considered a more important topic than functions of several variables.

The survey indicates business faculty members are looking for a substantially different course. Skill with modeling data to formulas was in the top half of the objectives for all respondents. Skill with using Excel for business problem solving was in the top half of the objectives for two thirds of the respondents, which had it more highly ranked than any of the computational objectives.

To a large degree the survey confirmed what the author had gathered from anecdotal evidence and the results of the CRAFY report. The student learning outcomes for business calculus desired by the faculty of the business school differ from the learning outcomes implicit in the current structure of the course. They are looking for a course that is more conceptual and less focused on computational technique. They are looking for a course with greater use of business technology, use of data, and applications. There was also an unexpected difference in ordering of importance of topics. The business faculty considered partial derivatives to be significantly more important that integration, while the final exams showed that the teachers placed much more emphasis on symbolic integration.

This study will help provide a baseline for determining objectives of student learning that should be measured in a further study. It will also lead to an adjustment to the syllabus to make both the standard and reformed sections more responsive to the needs of the client discipline.

Audience questions:

1) As the larger project moves forward, the author anticipates replicating this study with faculty from other business schools. What changes should be made to improve the study and gather better information.

2) For a period of at least two or three semesters, business calculus will be taught in both a traditional manner and in an Excel based approach. While the goals and syllabi will overlap, they will be distinct. What data should be gathered during the transitional period? (Possibilities include: responses to student evaluation questions about how much time the students put into the course and how relevant they see the course as being to their major, how student grade performance compares on an economic course that has business calculus as a prerequisite.)

3) Part of the larger project includes producing materials that allow the course to be effectively taught by adjunct faculty with a background in mathematics, but little training in business. What data should be gathered to evaluate the effectiveness of the teacher material?

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