Business and Management

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Summary

Mathematics Departments can help prepare business students by stressing problem solving using business applications, conceptual understanding, quantitative reasoning and communication skills. These aspects should not be sacrificed to breadth of coverage.

Problem solving includes developing and applying appropriate abstract models and an understanding that many quantitative problems are ambiguous and uncertain. Business faculty would like their students to be comfortable taking a problem and casting it in mathematical terms. Conceptual understanding can be fostered by motivating the mathematics with the "whys"– not just the "hows." Quantitative reasoning includes becoming familiar and comfortable with the language of mathematics and the application of mathematical reasoning to quantitative problems. Quantitative literacy can also be developed through the use of the technological tools of business, such as spreadsheets, as distinct from software whose primary applications are in science. Communication skills can be developed by having students work in teams and communicate solutions through oral and written reports held to the same professional standards they will meet in the business world.

Business students, although able, are often math phobic. Courses should strive to lessen math phobia, enable students to be more comfortable with mathematics, and help students appreciate the relevance of mathematics.

Narrative

Understanding and Content

In general, business faculty are less concerned with specific course content than with developing quantitative literacy and analytical ability in our students. Upon completion of a business mathematics curriculum the students should be comfortable with using mathematics as a tool to communicate analytical concepts. A measure of the curriculum's success is the students' comfort level when exposed to a new formula in a business class.

When in doubt, mathematics faculty should cover *less* material—and treat the material covered with respect—imparting to the students a sense of the importance of mathematics as a necessary part in the development of successful business people.

Business decisions are most commonly made under conditions of uncertainty and risk. Inferences must be drawn from data and information that are incomplete, inconclusive, and most likely imprecise. Wherever possible, math courses should attempt to illustrate this ambiguity and provide guidance in dealing with such uncertainty and variation. Sensitivity analysis can be used to demonstrate how changes in

assumptions, variation in data, and the influence of contextual variables will affect outcomes. This approach will facilitate a more in-depth understanding of the interrelationships and interdependencies embedded in real world situations.

In order to achieve the desired outcomes, the business faculty recommends that the curriculum include:

1. Realistic business problems. We do not expect mathematics faculty to develop problems on their own. We envision a partnership, in which business faculty contribute.
2. Solutions that make use of business technology, such as spreadsheets.
3. Real (or realistic) data sets.
4. Problem motivated modeling.
5. Development of students' abilities to express ideas symbolically.
6. Sensitivity analysis.

Algebra is a basic prerequisite to study in business, and should either be validated by a placement test or taken before the business mathematics curriculum. Students should be able to solve simultaneous equations, understand the concept of a function and functional relationships, understand the use of common functions in modeling business concepts, construct and understand graphs, and use abstraction to build simple models.

Calculus in the business mathematics curriculum should emphasize the basic concepts and how they apply to business problems, with more attention to numerical methods and less to techniques of symbolic differentiation and integration. The business calculus curriculum should include an introduction to rates of change, and the dynamic nature of real world systems, constrained optimization, and interpretations of area under a graph.

Statistics and probability in the business mathematics curriculum should include measures of central tendency and dispersion, probabilities (including conditional probabilities and decision tree analysis), discrete and continuous probability distributions, and hypothesis testing. Students should examine, summarize, analyze, graph and interpret real data sets used in business.

In virtually all business schools, there is a requirement for an additional statistics course beyond the introductory course in basic probability, usually taught by business faculty. Regardless of who teaches this course, it should also be integrated seamlessly into the business mathematics curriculum.

Technology

Technology has several roles to play in the business mathematics curriculum. First, it provides tools that students will encounter in the work place. Second, it enhances the effectiveness and efficiency of the learning process. Third, it can help to deepen and maintain student interest.

Technology has revolutionized the way in which business is practiced. Loan payments, the value of a bond, the effect of a change in sales on net income or the price of an option are computed with a financial calculator or a spreadsheet. Debits and credits, and journal entries no longer dominate the teaching of accounting classes. The algebraic manipulation necessary to compute present and future value no longer dominates finance courses. The business leaders of tomorrow, and therefore the business students of today, need to understand the conceptual basis of algebra, calculus and statistics. They must be able to interpret and use the results of calculations. The accountant has changed from a bean counter who reports what has already occurred into a business planner who assists charting the future course of the company. The finance executive has to be able to quickly evaluate several competing alternatives with risk and expected returns. For business executives to be successful, they need proficiency in the technology that produces the data they need, understanding of the algebra, calculus and statistics underlying these data, and knowledge of how sensitive the results are to changes in the input data.

Spreadsheets are very useful in charting data, conducting exploratory data analysis, developing models, demonstrating impact of changes on the inputs on the outputs, carrying out parametric analysis, and in more sophisticated applications such as optimization and simulation. Their potential should be fully exploited in the classroom, and the classroom use should be complemented with hands-on experience for the students in computer labs. The labs can be self-directed and rely on tutorials available on the web or prepared for the class, or they can take the form of instructional labs or workshops supported by teaching assistants, depending on the needs and resources of the institution. Students could repeat the in-class exercises or work on assignments and projects in the labs.

Specific technology goals for the curriculum include:

1. Comfort with the use of technology as an analytical tool.
2. Integrated spreadsheet experiences starting with mathematics and continuing in subsequent courses.
3. Using technology to answer "what-if" questions.
4. Encouraging students to experiment and try alternative approaches to a problem.
5. The use of realistic data.
6. Enhancing students' ability to design an experiment and find data, e.g., from the web.
7. Enhancing students' abilities to explain calculations and prepare a clear, effective presentation.
8. Enhance students' abilities to display results graphically.

Instructional Techniques

Useful pedagogical techniques include questions to make students think about a problem or a concept, asking students to discuss questions amongst themselves, and inviting students to share their proposed solution to a problem with the class and asking the rest of the class to critique it. A very effective active learning method is real-time problem solving or model building using student input in class. Starting with a blank spreadsheet on the screen and filling it out using student suggestions and instructions gives students a sense of control over the lecture and draws them in. Another potentially useful method for drawing students into the lecture is to start the lecture with a real-world (or realistic) business problem. If students are convinced that the problem is worthy of their attention, and that they do not know how to solve it, they are much more likely to pay attention and to retain what they learn. It is important to get the buy-in at the beginning.

Many business courses attempt to develop and reinforce skills that are highly valued by employers such as group work and communication skills. We believe these skills can and should be emphasized in mathematics courses as well. Students could work on group projects or assignments, and be asked to prepare written reports or oral presentations to communicate the results of their analysis. The ability to work effectively in groups and the ability to explain quantitative concepts and results in plain English are highly valued skills in business schools, and emphasis of these skills in first-year courses would achieve a more seamless transition to business school for students.

Business students are anticipating entry into the business world. Faculty should expect that the materials that students are asked to prepare are analogous to materials that they will hand to their bosses in the business world.

How Do We Get There?

Critical to the accomplishment of goals above are cooperation and communication between the business and the mathematics faculties. The willingness to change will be built upon personal relationships. Collaborative identification of clear objectives, and creation of the corresponding pedagogy, will build the foundation for successful implementation. The probability of lasting change will depend on the monitoring and assessment of relevant performance measures.

Specific suggestions for moving towards the goal of improved mathematical competence of undergraduate business students include:

1. Improved communication and collaboration between business and mathematics faculty.
2. Treating the selection of instructors for business mathematics courses as equally important as the selection of instructors for other mathematics courses.
3. Development of a seamless course structure, where students and faculty see the mathematics curriculum as integrated with the business curriculum.
4. A shift from business mathematics viewed as a method of weeding out students to business mathematics with the purpose of adding value.
5. Improved availability of business faculty for providing motivating examples and background for business mathematics.
6. Encouraging active dialogue between MAA and AACSB, and between mathematics and business, at regional and national business conferences.
7. Recognition that each school is unique, and that no single business mathematics curriculum will work everywhere.

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APPENDIX: Research on Business Education

Business faculty members conduct substantial research on pedagogical issues. Periodic reviews of business education journals by CRAFTY would keep MAA current on business pedagogical issues and provide CRAFTY with mathematics initiatives and excellent business examples. The business education journals include: *Financial Practices and Education, Journal of Financial Education, Journal of Economic Education, Accounting Educators Journal, Issues in Accounting Education, Journal of Management Education, Journal of Marketing Education, INFORMS Transactions on Education,* and *Journal of Education for Business*. Research on business education is taking on an increasing importance as AACSB assessment expectations rise. In reaction, pedagogy is rising in importance and new pedagogical journals are under consideration; for instance, the Decision Sciences Institute is planning an education journal for Information Sciences. The business environment is rich with a variety of activities. There are a number of business pedagogical seminars sponsored by foundations such as the Lilly Foundation. Book publishers often conduct seminars on learning theory and the learning impact of their products, and professional associations such as the American Marketing Association, Academy of Management, Decision Sciences Institute, Financial Management Association, American Accounting Association, and the American Economic Association routinely sponsor teaching and learning sessions.

AACSB constantly monitors changes in the business environment and the corresponding changes in business education. Through networking with the AACSB staff, CRAFTY can stay apprised of the latest expectations in business content and technology. Then, real-time changes in the content-pedagogy-technology triad can be promulgated to departments of mathematics. CRAFTY reviews of the two-year mathematics curriculum might thereby become semiannual or annual rather than decennial reviews. An added benefit of this reduced review period is that mathematics faculty members become increasingly knowledgeable business school partners.