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REORGANIZING FRESHMAN BUSINESS MATHEMATICS II: AUTHENTIC ASSESSMENT IN MATHEMATICS THROUGH PROFESSIONAL MEMOS

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Abstract: Part I of this paper described the development of a new Freshman Business Mathematics (FBM) course at our college. In this second part of the paper, we discuss our assessment tool, the business memo, as a venue for students to apply mathematical skills, via mathematical modeling, to realistic business problems. These memos have proven a crucial step in turning our FBM course around from a dreaded course with little connection to students' intended careers into a course where students experience the power of mathematics for solving problems and informing decisions. Comments from students in the course throughout its six-year history clearly point to the course's value and importance.

1. INTRODUCTION

Teaching mathematics courses for students outside of mathematics and science presents many distinct challenges. When the students involved are planning to pursue careers in business, the challenge of motivating them to study and learn mathematics seems to be even more difficult. At the same time, since business professionals represent a large fraction of the work force, and these individuals will be in control of budgets and make decisions that impact every corner of society from government spending on science to local educational initiatives, it is vitally important for mathematicians to connect with this audience. In this paper, we will explore our method for developing authentic assessment activities that play an integral part in student learning, motivation, and success in the mathematics course for business students that we developed. The students are majoring in general business, marketing, or management at a four-year liberal arts college in a program accredited by the American Association of Colleges and Schools of Business, and our course is a required component of the program. Based on beginning

of semester surveys we have conducted since the course's inception in the fall of 2000, we know that many of these students tend to have some anxiety about mathematics and a degree of distrust in why they are taking mathematics, since the procedural, algebra-driven courses of their past seemed to have little connection to making decisions in the business world. These beliefs are entirely consistent with those reported by Falsetti and Rodriguez (2005) for students in a first-year university modeling course: they feel unsure of their ability to use mathematics for anything other than problems like those presented in class, they do not understand the reason for the procedures or objects involved in mathematics, and they tend not to reason about mathematical situations. However, the business school at our college has adopted the view that mathematics will be useful to their students in their business careers, and asked us to redesign the former one-semester, finite math plus calculus experience, as discussed in part I of this paper. For this course to succeed, though, we had to find a way of motivating the students to engage in the mathematics; otherwise, we expected very little difference in student interest or ability when compared to the traditional one-semester course in finite mathematics and calculus.

Although the business memo format was not part of our first attempt at designing authentic assignments for this course, we eventually developed a set of weekly assignments framed as professional memos to the students. The memos come from a fictional boss at a fictional company, and call for the students to perform some sort of data analysis task. They report their results back in a formal memo. They then receive detailed feedback in the form of a COGS matrix (Green & Emerson, 2007) and are expected to revise and re-submit their work. After a great deal of work to develop them, these memos have become central to the course, and are often cited by the students in course evaluations and reflective essays as the most important part of their learning experience in college. The memo format of the assessments provides us

with answers to many of the problems we encountered with other methods of assessment in this course. Along with the grading system and associated feedback sheets we developed, these memos have become integral to the entire teaching and learning process.

In what follows, we will briefly discuss authentic assessment, particularly in contrast to traditional modes of assessment in mathematics courses, with an emphasis of the typical sorts of difficulties that authentic assessment mitigates. In our course, mathematical modeling activities, often of an empirical nature, are at the heart of each memo, so some overview of mathematical modeling will be provided, especially as it relates to authentic assessment, as there are many parallel features. We next describe how we developed the memo assessments; necessity, as they say, is the mother of invention. This is followed by a discussion of the memo format and the communicative context it creates. Next, we provide a brief overview of our grading methods and other features of the course, such as particular software and pedagogical strategies, which support the memos and make such work possible in a day-to-day classroom environment. We then present an analysis of what students seem to get from such an experience that makes all the work on the part of everyone worthwhile. We conclude with some thoughts on how to apply these ideas to develop memo problems for other courses and situations.

2. AUTHENTIC ASSESSMENT AND MATHEMATICAL MODELING

Authentic assessment has been referred to by the MAA (CUPM, 2004, p. 18) and other groups urging reform in mathematics teaching. In *Educative Assessment*, Grant Wiggins defines "authentic assessment" as a form of assessment that

1. is realistic;
2. requires judgment and innovation;
3. asks the student to 'do' the subject;
4. replicates or simulates the *contexts* in which adults are 'tested' in the workplace, in civic life, and in personal life;

5. assesses the student's ability to efficiently and effectively use a repertoire of knowledge and skill to negotiate a complex task;
6. allows appropriate opportunities to rehearse, practice, consult resources, and get feedback on and refine performances and products (Wiggins, 1998, 22-24)

Such assessments are focused on providing students with situations as similar to those they will face on the job and in real life as possible. These problems are focused on real or realistic data and provide genuine contexts related to real situations that require solutions. Using such approaches seems to result in more motivation and interest on the part of students (Falsetti & Rodriguez, 2005) to complete assignments, since they immediately see some connection outside the classroom. There have been many successful models of authentic assessment introduced, including service learning projects where students/student teams become consultants, portfolios in which students select their best work for presentation and critical self-analysis, and performance-based examinations.

In mathematics classrooms, many examples of authentic assessment come in the flavor of mathematical modeling, for example asking students to evaluate a design for a building in terms of minimizing pedestrian traffic during an emergency. Another group of authentic mathematics problems involves problems of a statistical nature. These types of authentic mathematics problems seem easier to develop than problems from so-called pure mathematics. Many involve numerical analysis or computer programming. But these are not exactly the kinds of problems discussed here. Our memo problems are similar in their use of modeling and statistical concepts, but the problems discussed here are designed from a central perspective that provides a context for an entire semester of mini-projects to aid in student learning, rather than a single authentic problem for a summative evaluation of student learning. Furthermore, these authentic problems are couched in a communicative context that students see as relevant to their futures. They

provide answers to many student questions, especially of the "why do I have to write and explain my thinking" and "why can't I have another week to get it done" variety.

There are some obvious problems with using authentic assessments in the classroom, as anyone who has attempted their use can attest. One of the most critical questions deals with student learning. If the scenario is truly authentic, the multiple solution paths in the problem make is difficult to ensure that students learn what you want them to learn or demonstrate a mastery of particular content in their solutions. It is also difficult to find real data and develop good problems, at least in isolation, especially if one is trying to use the data to teach a particular concept. Additionally, anyone using mathematical modeling knows that it takes more time than other approaches, thereby reducing the quantity of topics covered in the curriculum. Even more critical is the bottom line of education: how does one evaluate fairly such disparate student work?

Traditional modes of assessment certainly mitigate many of these concerns. Since all students are essentially implementing the same solution procedure, fair comparisons across students are easy to make and students all seem to be experiencing the same learning process. Since the problems are all short slices that have been pre-mathematized, many of them can be assigned for completion. However, these traditional modes of assessment also have problems. Students are often unmotivated to learn mathematics when it is too abstract. Students with different learning styles approach drill and practice problems very differently, circumventing the appearance of everyone learning the same things. Another problem with drill and practice scenarios is that students often learn unintended lessons. For example, the emphasis placed on linear and proportional problems can lead to an over reliance on linear thinking where students apply inappropriately, even in the face of common sense (Van Dooren, De Bock, Hessels,

Janssens & Verschaffel, 2005). Most important though, is apparent fact that students have difficulty transferring to the real world the mathematical skills learned in the abstract. The work Nyman and Berry (2002) shows that mathematical modeling is a powerful tool in helping students reify their abstract mathematics. Thus, mathematical learning shifts from the learning of the abstract procedures and apparently arbitrary rules (Falsetti and Rodriguez, 2005) that are occasionally applied to template-style word problems, to a process of solving problems using quantitative information.

Math modeling competences (Blomhoj & Jensen, 2003) are closely related to the steps of real world problem solving, making experience in modeling a direct match with the goals of authentic assessment. However, Blomhoj and Jensen admit that having students implement all six competences is time consuming, and they raise the question of whether modeling is best learned holistically or whether focus on specific aspects of the modeling process, like mathematization and analysis, is more effective. Many "real world" mathematics problems start with several of the stages of problem solving already complete. This is often done to avoid the loss of time associated with exploring a problem situation and to provide students more opportunities to see more applications of mathematics. In the end, though, a balance between the two approaches is needed; it is crucial for students to experience all aspects of modeling, including the definition and refinement of the problem. Although not directly listed, the "mathematical practices" referred to by Boaler (2001) are similar, and Nyman and Berry (2002) consider that these skills are the ones that are transferable to other contexts, as opposed to knowledge of specific mathematical techniques and procedures. Without exploring all stages of the modeling process, students will not be experiencing authentic problem solving. They must

have the opportunity to confront an ill-defined problem, clarify it, refine it, search for methods that might be useful, mathematize it, solve it and interpret and evaluate the solution.

Our goal is to bring all of this together in assessing students. By seeing how they perform in their use of mathematics in realistic situations, then using this to develop deeper or broader mathematical ideas, we can help students connect their abstract mathematical skills and their real world knowledge and interest. Through these activities, we can provide motivation for new mathematical techniques to provide more efficient solutions or solutions not possible with previously learned techniques. Finally, it is our belief that most assignments completed during a course should support student learning, rather than assess what learning has taken place. This means that students are being formatively assessed to help guide future instruction and are receiving frequent, individual feedback regarding their progress. Through revisions of these memos and an examination of student work on them over time, we can produce a summative evaluation of students, which can be supplemented with other forms of assessment (Green and Emerson, 2007).

3. OUR FIRST ASSIGNMENT

In part I of this paper, we described the course itself, particularly its goal of having students explore realistic business scenarios using mathematics and technology, with a strong focus on understanding and interpretation, rather than simply on procedural techniques and calculations. To a certain extent, this was part of our plan for the course from the beginning, but as we all know, "no plan survives contact with the enemy." We ran into a significant snag on the first day of the first semester, when the two of us, team teaching the course together, realized that the first chapter of the text we had selected was more conceptual in nature than computational. It set up the different kinds of models one could use to make quantitatively informed decisions and

provided an overview of the problem solving process. Worst of all, there were no small, practice-oriented problems at the end of the first chapter. One of us (Allen) has a standard reaction to such chapters and material – "I don't teach it unless I assess it." Unfortunately, both of us were all too aware of the importance of the chapter for helping these students see the relation between real situations, the data describing them, and the methods of analyzing the data, so we knew that we had to have students do something with these ideas in order to experience them.

Fortunately, there was a one-page case study describing a situation on a cruise ship (see figure 1). So, five minutes before our first class of the semester, we settled on this as our first assignment. The instructions we gave were simple: students were to provide one typed page of narrative to tell us how they perceive the situation, based on the case study presented, and what they would do to find out more in order to design a solution strategy. Their narrative was required to answer each of the questions raised, and they should summarize their ideas with a conclusion about how to proceed.

One week later, we collected their work, grading it much the same way we expect most math faculty grade any assignment. Armed with a list of expected errors and point reductions for each, we tackled the stack of papers. As we graded, the list of potential errors expanded. By the end, we compiled the list shown in figure 2 and were, overall, dissatisfied with the results (figure 3). At first, it seemed to us that students didn't know how to read or write. But that was being unfair to them. After all, they had probably never had such an open-ended assignment in a class before, especially a math class in which they expected to play the traditional educational game in order to emerge with some dignity.

One major problem was that students responded to the case study as a series of discrete questions with no connection or flow – despite the stated expectation that their response be a

narrative. While this may seem style-related, and thus outside the purview of a mathematics assessment, this style was insufficient to handle the complexity of the problem, since most of the questions were inter-related, and none of the students responding to the questions discretely was able to connect the different questions. A larger issue was that students tried to solve the problem of low attendance at the entertainment and suggest solutions, rather than getting at whether there was a problem. They made unwarranted assumptions about the validity of the writer's observations. They assumed that what they were presented in the case study were the only possible explanations for the situation, rather than considering other options. And, worst of all, they did not discuss ways in which collecting and analyzing data would help them either determine the actual cause of the situation, and thus point to a solution, or whether the problem even truly existed, since all the information was based on anecdotal data, at best. To be sure, many students exhibited creativity in their responses to the perceived situation, but many of these plans involved great expense without any evidence being collected to determine whether this would even help.

When something like this happens – an entire class of students responds to an assignment in an unexpected manner – one can either bemoan the preparation of today's youth, or apply Occam's Razor. It was probably not all the students, but the assignment itself, that needed fixing first. One problem was definitely the way the case study was framed. For example, we asked for a "conclusion". In our mind, the conclusion would be a plan for collecting data to analyze the problem, not a solution to the perceived low attendance, but what do math teachers typically mean by "conclusion"? Thus, students tried to give us final answers, not realizing that the point was to focus on the process by which one would arrive at a solution. Another problem with the framing was the discrete, numbered style of the questions raised during the case study.

We initiated some class discussion to address the shortcomings in the papers and moved on. But the more we assigned traditional sorts of problems or even small project-like assignments, the more we returned to this first assignment and thought about how much deeper the thinking was (or could have been) there. We suspected that we had an opportunity to integrate more writing with our quantitative field here and sought ways to do this since both of us are committed to using writing across the curriculum to enhance student learning. It became clear that the only way to get better responses was to restructure the assignment.

It is important to note here that most of the other course assignments looked more like traditional mathematics assignments – lots of smaller problems to provide practice with the procedures and techniques with short explanations required to explain the concepts involved and their application. Student response was relatively poor, with the class, on average, ranking homework in the middle of the list of class activities with respect to its usefulness and near the bottom with respect to whether they liked it. However, an voluntary online survey completed anonymously by 15 out of 23 students in this first class (65%) did point to some interesting results. In response to a question about their opinion regarding the revisions to homework, 77% of respondents claimed it was “very helpful to get a chance to correct my mistakes,” while only 23% marked “I never really took advantage of it.” None of the students marked “I think re-doing something I turn in takes too much effort” or “I have no opinion on this subject.” When asked about the amount of writing in the course, none of the class marked “too much writing for a math class”, and only 8% had no opinion. The remaining students either marked “It was okay” (62%) or “It really helped my think about the material” (31%).

4. INTRODUCING A COMMUNICATIVE CONTEXT

We jokingly considered the problems with the first assignment as being "rhetorical problems". Later, in considering rhetoric as a means of persuasion, we stopped laughing and started working. So we modified the assignment for the following semester, trying to be more specific about what we expected students to do – and why. This eventually resulted in a rhetorical split: we needed to separate our directions from the case study of the situation. But we needed a natural approach to this, one that maintained the authenticity of the situation without adding too much "teacher talk". One of our dreams had always been to treat a course like a consulting firm, where a student's grade would be measured by their salary, so we tried to produce a similar feel by phrasing the case study as a Request For Proposal (RFP) and placing the "what we expect done" in a memo from the boss of a fictitious consulting company. This natural communicative context would prove to be the turning point in our course development, driving us for years to come. This version of the assignment was tested and modified over several semesters, eventually settling into the form shown in figure 4.

By "communicative context" we mean writing to an audience with a meaningful purpose, something other than just fulfilling requirements for an assignment (Green, 2002). To accomplish this, we made a few small changes to the initial wording of the case study and added a page to the assignment itself. This one added page consisted of a professional memo tasking the students/consultant to respond to the case study in order to help the firm land a client. This effectively transformed the classroom into an imaginary consulting firm – Oracular Consulting. Instead of proving to the teacher that students understood the chapter and could use the problem solving approach discussed, they became consultants trying to help our firm win a contract from the cruise line director, Ms. Salena Way (a pun which many of the students miss). The memo

itself discussed an RFP from Ms. Way and detailed what the boss expected from the consultants and where in the entire contract process the consultants' work would fit.

The key features that seemed to make this work all stem from the memo itself. No longer were students writing to the teacher to prove they knew something or could complete a particular task. They were writing to a particular audience, their boss, in order to address a (realistic) purpose, winning a contract. In this particular memo, the students were asked to consider Ms. Way's Request for Proposal (RFP) and respond. In particular, the goal was to convince the potential client that our firm had an understanding of her situation, an understanding of how data and analysis of that data might enlighten us, and a plan for acquiring and using these data. This format proved rhetorically useful by providing students with an audience and purpose for writing, as well as obvious rationales for both the format of their work as written explanations and the timing of the work. This last became even clearer to the students after a short dissection of the memo, illustrating the different project personnel that will become involved only after getting the plan from the student.

Even more useful than the rhetorical gains from the memo format, students also focused more on what was asked of them. Since the company is trying to win the contract, it became clear to students that they were not expected to solve the low attendance problem for Ms. Way, at least not until our company won the contract. Rather, they were to convince her that they had a plan that would collect the data needed to identify the problem and suggest solutions. We hypothesized that this rhetorical distance from the problem would force the students to focus more on the process of solving the problem and seeing the role of data in the solution, rather than on trying to solve the problem itself. This, in fact, is what happened. Students then deepened their analysis of the problem– the first step in solving a problem – and focused more effort on

where data existed or could be brought out in order to both determine the nature and seriousness of the problem as well as point toward possible solutions.

This is not to say that all of our problems were solved. Students still misunderstood various aspects of the situation and the context. Quite a few still tried to solve the problem for Ms. Way, but far fewer than before went this route. In order to capitalize on the good thinking that had occurred, we followed the assignment up with class discussion, after which students were expected to revise their memo.

This first memo had students explore the dimensions of the situation instead of attempting a solution to the perceived problem. As reported by Dias (2006), students can engage in this aspect of problem solving quite deeply and readily when the problem is connected to the real world. As Dias also shows, though, students can drop all of this excellent thinking in favor of simplified mathematical analyses. To avoid such as scenario, we designed follow up assignments. The second assignment pushed students to the next step, testing their data collection methods by designing survey and observational data instruments and creating a mock up of data from these instruments in a spreadsheet that was organized to facilitate analysis. We required that students demonstrate clearly how the data in the spreadsheet would have been directly collected from the data instruments. Many problems arise at even this simple stage, as students discover missing information in the forms or attempt to provide summary, rather than raw, data. A later memo provided students with similar observation-based data from the cruise line and asked for an analysis of any patterns using the mathematical tools developed to this point in the course and recommendations for how the cruise line should proceed based on these data. Using some basic word problems from the text as starting point, we then developed a number of memos covering other aspects of the course, basing them of different contexts than

the cruise line scenario. Eventually, we shifted the majority of the assignments in the course into such problems once we realized their power for authentic assessment (see figure 5).

5. SUPPORTING THE MEMOS: GRADING AND TECHNOLOGY

However, not all was perfect. In grading student responses to the memos, we ran into many problems, not the least of which was the time involved. Even worse, grading methods that we had used in the past proved ineffective in helping students learn from their mistakes. Students tended to look at the summary grade, whether a letter or a number, and ignore most of the typed comments we provided, wasting much of our time. We encouraged students to revise their work, rethinking the problem and deepening the analysis, but students often contained this to editing, rather than true revision. With any writing task in which the goal is to learn through writing, though, revision is an essential component to learning. These memos were designed as a teaching tool, not simply an assessment. We expected students to learn mathematical techniques, computational tools, critical thinking and writing skills from the process of completing the memos. To do this effectively and efficiently, we needed to treat the memos as formative assessment rather than as summative assessment and allow them opportunities for revision, based on feedback from the instructors. But with few students engaged in honest revision of their work, this could not occur.

After trying out a number of conventional approaches to grading and some rather unconventional approaches as well, we developed COGS, the Categorical Objective Grading System (Green & Emerson, 2007). In COGS, the instructors determine three course-wide learning goals that apply to all assignments. For this course, the goals involved learning (i) the mechanical tools and techniques to manipulate quantitative information, (ii) applications of these tools and reasoning about the information provided by the tools, and (iii) professional skills

related to writing and communicating. The instructor then develops a matrix for each assignment. The matrix is divided into three rows and two columns. Each row corresponds to one of the course goals, and each column corresponds to a level of performance, either "expected" or "impressive." In each cell of this three-by-two matrix, the instructor creates a checklist of items that, if present in a student's work, would indicate success with respect to the performance level and goal corresponding to the row and column of the cell in the matrix.

Authentic assessment also requires that students effectively use the resources and tools commonly available in the real world. Technology is one such a tool, and computer/information technology is particularly vital in the future workplace experience. For the students in this course, most of whom will enter the business world in some fashion, spreadsheets are possibly the most ubiquitous and important tool in use today. Every memo of the course except the first is accompanied by a spreadsheet data file or requires that the students construct their own spreadsheet. In addition to this, our memos provide students a opportunities to communicate using electronic communication systems and to construct professional documents using a word processing package.

Each assignment is collected using the Blackboard CourseInfo system. This allows students to submit work to an electronic drop box. Student work can then be downloaded either one file at a time or in batch. The instructor then has electronic copies of student work. This provides a valuable tool, since students are not confined to handing in work "in class". Instead, instructors can collect assignments at any time that seems reasonable, based on the timing of the course. Collecting the work electronically also has an impact on student honesty, since these works can be submitted directly to plagiarism detection services, such as TurnItIn.com, or can be compared to other students' work using the "Compare and Merge Documents" feature of

Microsoft Word. This last feature is also vitally important in evaluating revisions to student work, since one can compare the new and old versions and simply scan the merged document for the differences, which are highlighted for you. Comparing these changes to the feedback provided to the student greatly speeds the process of evaluating revisions.

We also experimented with the markup feature of Microsoft Word for commenting on student work, but encountered problems with this. First, once you highlight a passage and add a markup, you have to send the file back to the student in order for them to have the feedback. This can take an enormous amount of time if one's system is not set up for batch processing. Second, since the instructor must attach comments to a particular word, phrase, or sentence, students tend to focus only on the highlighted portion and ignore its place in the surrounding sentences and paragraph. Thus, they often correct a local mistake, but fail to recognize the global issues being pointed out. Finally, even though one can construct a file of all your comments as you grade in order to facilitate cutting and pasting similar comments into multiple files, this process takes an enormous amount of time. During one semester of experimenting with these tools we found ourselves spending about twelve hours per week for a section of twenty-four students.

From the student perspective, the most important tools in the course are the spreadsheet and the word processor. And while students learn many specific tricks and tools in Excel during the course, these are not the most important ideas students take away. We believe it is more crucial for their analytical ability that students learn how to *think through spreadsheets*. By this we mean that students develop some facility with organizing data effectively, exploring and analyzing data with various tools, and designing worksheets that allow students to probe the logical connections among the quantitative information in the problem. As an example of this, when attempting to find an algebraic model for some real data, one must organize the data, the

parameters one is using to fit the model to the data, and the computational or graphical tools that will allow one to evaluate the quality, accuracy, and usefulness of the model. This also requires that students develop ways to systematically and efficiently explore the space of possible parameters in the model, using their mathematical knowledge to reduce this as much as possible.

In using the word processor, students also learn a variety of neat tricks for inserting graphs and formatting a document. They gain experience with communicating electronically and writing professionally. But the general principle they take away is *document literacy*. They learn how to structure information that contains a wide variety of formats – numbers, text, graphs, and equations – in order to effectively communicate ideas. This knowledge will not only help them in preparing materials of this type, but also in reading such documents.

By the end of the semester-long course students have typically completed ten memo assignments and their associated revisions. These memos cover the entire range of modeling competences and mathematical topics in the course (see figure 6).

6. WHAT STUDENTS LEARN FROM THIS EXPERIENCE

In our grading system, all three areas (mechanics and techniques; application and reasoning; communication and professionalism) are equally weighted. While this may seem to focus the content of the course away from the mathematics, which many would argue is found primarily in mechanics and techniques and, to some extent, in application and reasoning, but not in communication and professionalism, we feel strongly that this is not the case. First of all, if one cannot interpret the meaning of the work (the mechanics and techniques) one has done, then one cannot use it in the workplace. Thus, application and reasoning is important. And even if one can perform the work and interpret it, without a clear explanation of the work and its meaning, one's understanding is incomplete and one cannot function effectively in a team, implying that

communication and professionalism is an essential component. Without all three, the connection to the workplace is lost. Having the three areas weighted equally also allowed students to focus their efforts on improvement at specific aspects of the assignment when dealing with revisions.

This does raise a potentially serious concern. Students can achieve similar grades with very different performances. For example, knowing a student achieved a letter grade of B carries with it the knowledge that the student has achieved the minimum expectations in all three areas and has achieved superior performance in one area, but not which area. On the surface, this implies that everyone does not necessarily "get" each topic the same, especially since you are evaluating their effectiveness in memos to analyze the problem which may take them along a different path than you expected or intended. But you must accept this apparent drawback to the system, while simultaneously providing them feedback to help them consider alternate paths involving other approaches and techniques. We used the phrase "apparent drawback" to emphasize that this is not any different from normal grading or learning with respect students learning different things from a course. Using a percentage grading system calculated using the mean of various grades only provides an illusion of objectivity and similarity (Guskey, 2002).

Another concern with respect to student learning might be the mathematical sophistication that students work with during the semester. Many of the topics can be found at lower levels in other curriculum materials, such as basic descriptive statistics or linear models. However, students still have trouble with these topics. Even more critical is the distinction between compartmentalized learning and integrative or situative learning models. By this we simply mean that individually, many of the mathematical tools are not difficult; it is the combination of tools and techniques, along with analysis and explanation makes the overall task difficult. Students are used to seeing the components pieced out in their education, and this

inhibits their ability to transfer learning to other contexts. Integration is new to them, but will be expected in the workplace. How can we claim to be preparing them for this without providing them with similar opportunities?

One of the most important student learning outcomes of the course is the impact it has on thinking. The key to transforming students from passive receivers of mathematical facts and procedures into analytical thinkers using quantitative tools was the use of realistic business writing. Through these memos, students not only demonstrated procedural ability, but also the ability to apply these quantitative ideas to realistic problems and to communicate this effectively. Writing has long been considered a vital tool in developing thinking. It has a powerful ability to reinforce learning, to demonstrate understanding, and to prepare students for tying together sentences in the workplace for effective communication. The reflective nature of writing forces students to consider why this graph or calculation is important to the problem solution and how they made use of it. This, in turn, reinforces connections between the real world, the mathematical world, and the student.

One of the most unexpected changes we have seen in student thinking is evidenced in their ability and willingness to tackle problems even when they do not know the "right" approach up front. Many of us have seen students sit and stare at a mathematics problem, waiting for some type of insight to occur or some form of *deus ex machina* to save them. Watching students in our course, however, has shown us that students can break out of this nonproductive behavior. In many cases, our students will read a new problem and immediately load the data. Very quickly they will begin exploring the data – looking at the variables, calculating some descriptive statistics or correlations, making graphs – in short, doing anything to give them more information. In the words of a typical student:

> "This class has given me the first step in the direction of thinking on my own. When faced with a problem or situation, like in our assignments, I normally would sit with no idea how to approach it. I have been used to being told what to do and how to do it. Now, there is not so much hesitation to just start to brainstorm ideas and test them with the given information." (Student from spring 2003 semester)

Falsetti & Rodriguez (2005) have presented quantitative data that modeling-based activities can have a positive impact on student beliefs and expectations of mathematics. In particular, they show the strength of such an approach for helping students develop an understanding of the utility and power of mathematics as well as changing student interest in mathematics. And while our course is significantly different in the depth and complexity of the problems considered, comments from our students directly support their conclusions… Boaler (2001) has demonstrated that students experiencing mathematics through modeling activities tend to see mathematics in their world more readily. This enhanced perception of the usefulness of mathematics in the real world is critical if students are to become analytical citizens, capable of making evidence-based decisions, which is the main reason the business school at our college wants its students to have strong experiences in mathematics. So far, this seems to be happening.

We collected mid-semester surveys from both sections of the course in spring 2003, at the point where the memos had finally "taken over". Out of 53 students responding to the five questions, there were a total of 121 statements in reaction to the style of the homework – the memos and the revisions. Of these, 23 (19%) mentioned the importance of the homework in helping them learn and understand mathematics better. Another 23 (19%) mentioned the value of the revisions for helping them re-think the problem and improve understanding. The importance of Excel was mentioned by 20 students (16.5%). Many students mentioned that the homework was long or difficult (22, 18%) with a variety of other responses included in the remaining 33 statements (27.5%). Over half of the 65 statements reacting to the feedback students received on

homework were positive in some way (36, 55%). Most surprising of all, though, are the comments in the last question of the survey, which was a completely open-ended question, "Any thoughts you'd like to share on the course?" Of the 70 separate statements we identified, 6 (8.5%) said the course was valuable for business and 11 (16%) claim that the course was "cool or interesting."

In the most recent semesters, spring and fall of 2006, the end of semester campus-wide, anonymous course evaluations included the open-ended question "Which aspects of the course did you find most beneficial to your learning?" In both semesters, more students mentioned the memos as beneficial (5 in each semester, out of 20 responses in fall 2006 and 25 in spring 2006) than mentioned the use of Excel (3 in fall, only 1 in spring). When looking at a similar item from surveys at the end of the second semester the course was offered, spring 2001, one can see just how far the course has come in meeting students' needs and interests since introducing memo-style assignments. In that semester, homework was ranked in the middle for usefulness by the class (fifth out of nine items) and near the bottom (eighth of nine) for whether they liked it.

We often collect short reflective memos from the students at the end of the semester. This helps the students reconsider the entire course and structure their experience before taking the final examination. The reflections are open-ended, with students simply asked to reflect on the course, but we usually mention some aspects to think about in order to prime their thinking, such as memos, Excel or business applications. The goal of these reflections it to help the students, but the comments students make are often enlightening. We share some typical comments below, grouped into the themes that we have found repeated throughout the reflections.

Comments related to how the course impacted their thinking process

"[This course] has taught me that I can make important decisions by just simply collecting data. Thus, I believe this course is valuable for any student that is going to have to use data to make decisions in their career."

"I have really enjoyed this class and think that this class should be required for all majors. It keeps your mind thinking with the math problems and the knowledge of computers and writing will come in handy to anyone in any profession. I think that this class has taught me how to interpret complex problems, through numerous examples, and how to properly address them."

"The constant memos kept the employees/students informed of our job/assignment at all times. I learned that you really need to pay attention to detail. You must complete everything your boss/teacher asks you; your job/grade depends on it. You also need to go that extra step above everyone else. I may be competing against numerous other employees some day for a higher position, doing the average won't win me that top position. I learned that you need to go out of your way to go above the rest of the crowd if you really want to succeed and do well."

"The answers were almost never provided to us, nor were they "common sense." We often had to dig deeper than that to come to the many conclusions. I think that's what I liked about the class… This class requires you to push yourself. At times I must admit I got extremely frustrated and had to walk away from it for a little while, but when I came back I couldn't wait to get through it."

"I have always hated math and never understood it, but this math was more logic more reasoning and seeing about situations and what can be solved all applying math. Math isn't as meaningless as my entire high school/college career has taught me to believe… I understand that its not so much the 42 problems a night on dividing that you need, it's the thinking around it all that you eventually break down in use in the future."

Comments related to the real world connections

"The element of "real life" was the key to my growth in this class…we were taught theory in class by our teacher but the assignments were presented as if were being asked by our boss. This gave me a sense of pride to solve the problems. We were able, like real life, to ask questions to help solve the problems but in the end it was our own work we handed in. When we received feedback it also reinforced the sense of pride."

"Being given the opportunity to play the role of the manager and provide possible solutions to a variety of problems has given me a positive perspective on what to expect when analysis is necessary. Each assignment brought a different challenge; there was a problem that needed solutions and as a member of the staff, the advice I gave was submitted to consultants for possible consideration."

"For the first time in college I was learning something that I would use later in life, my mother works for a company off of Kodak and in seeing her work I saw such a relevance to future work."

"My idea of this class has changed drastically from thinking this was a class that I just had to get through, to a class that I felt was giving me good mathematical and analytical skill that I can use in the professional world."

"The problem solving I did for the homework was a great idea to expose me to "real world" problems… The professional structure of the homework always made me think that I was actually a real businesswomen dealing with real issues."

"The fact that the homework assignments as well as the in class exercise were based on real life situations was good too. Although this sometimes made the work more complicated or more time consuming it helped us to learn the information better. Also, in real life we won't be dealing with just numbers. We will have real problems and questions just like the ones in our assignments so it was good to get some practice working on them."

"This course has provided me with the most relevant assignments to that of the real world. Each and every assignment we were allocated presented us with a problem that could actually be faced sometime in the future, unlike many classes I have been enrolled in."

"Being able to revise our homework's was really nice because it made us be able to see what we got wrong and allowed us the opportunity to get a better grade… It sort of answered that question you always ask in high school: "when am I ever going to use this?" This course shows you how you are going to use analysis in a real job and I liked how we had to pretend we were in a real job situation when writing the memos. It made it seem like the work was not pointless. The course made me think about not only how to make a graph and how it changed as you increased or decreased one variable but it made me think of why things like that may happen. Looking at variables, such as with the railway exercise, makes it apparent that the littlest thing can have an effect on the way that an output might be affected."

Comments related to writing and revising

"The best experience of the class was actually writing the proposals and doing the steps of the homework. I believe most of the students did not have experience in this department, am I was no exception."

"…the important part was being able to interpret data into words that everyone could understand. This was very challenging because I have never done anything where intricate detail was so important."

> "The writing in the homework played a big part in my learning. I think I got more out of explaining what graphs, charts, and models meant, rather than just copying and pasting them onto a word document to submit. When I had to write about each step I took it gave me a chance to internalize the information that I was going to submit."

> "Also with writing memos it made you analyze what you have done and try to make it better… Revision does add to the workload of the class but if math is not your strength you learn to appreciate them… Overall I enjoyed the class and it has helped me achieve a new respect for math and I am now better prepared to solve business problems."

> "The revisions also provided an excellent opportunity for me to learn from my mistakes, and further reinforce the material that was to be learned in that specific homework… As any professor in college will tell you, writing is one of the most vital skills any person can have. It is the language of business, and I sure did learn this in MSTA 130. While it was predominantly a math class, I needed to express my findings in the form of written word. I think I realized in this class just how important writing skills would be for the real world, and my advancement in employment. Writing played a very important role in the success of this class… The material is very relevant to the real world, this is something that I picture helping me advance through life."

Comments related to grading

> "I felt that by doing this [giving rubrics] the grade you received was more justified because you knew exactly where you went wrong. You knew that you [sic] equations were rights and that you got full credit [for that aspect] but that because you did not explain it thoroughly you had your grade lowered."

> "The three areas of this course have in particular assisted with my learning. I feel that by developing a grading system based on three different parts is very effective, because it allows students to thoroughly understand each element that they performed well on, as well as those elements in which their performance was unsatisfactory. By doing this, students can be aware of the areas which they are good at, and also work to improve in areas in which they are not as skilled."

> "Personally, I find [the grading system] to be a very effective means of assessing a student's work. It's not as discouraging and gives the students a chance to revise and learn what they messed up instead of, "Here's your grade, better luck next time." I think you will see more of the student's capabilities and knowledge on the material if you evaluate rather than provide them with a grade."

7. WORKING MEMOS INTO OTHER COURSES

The memo format seems to offer many advantages to learning, and we have seen encouraging responses from students. Thus, it seems one could adapt them for use in other

courses. However, the single most important thing we have learned through developing and testing these memos is that creating effective writing assignments is challenging. And while one can find much advice for creating writing assignments for mathematics courses, their success depends on many factors. Two of the most important for us have been the framing of the assignment and the evaluation of the assignment.

Some of these factors involved in effectively framing the assignment are extremely subtle. As a broad analogy to the different ways one can frame an assignment to students, consider the sketches of three emails presented below, in which the email writer, the one throwing the party, represents the teacher and the students are the party attendees receiving the emails.

1. "Hi, I'm having a party at my house."
2. "Hi, I'm having a party at my house; here's a map."
3. "Hi, I'm having a party at my house; here are directions from your house to mine."

Email (1) is a truly real world problem; the party-thrower does not seem to care at all about where his guests begin their journey and leaves it entirely up to them as to how to get to the destination. Email (3) is a more template or structured problem – the "solver" only has to implement the steps as presented to them. This also requires that the party-thrower know where each guest begins so that she can provide each guest with a specific path from where they start to where they need to end. Email (2) is more like our memos; we give them some information that's useful, but allow for many solution paths, both in planning and implementation. This also does not require as much knowledge from the party-thrower about the starting point of each individual guest.

The most critical aspect of designing a memo problem is the realism of the problem and the techniques used in its solution. For example, we initially had difficulty in designing problems

that involve data-driven optimization to allow students practice with calculus tools. It was not enough to simply give students data, have them fit a function to the data, and then differentiate this function to locate the optimum points. After all, if the data has been collected over a plausibly large enough range of values, the maximum or minimum points should be apparent on a graph of the data with little calculus required. If the data did not cover the optimum points, then it may be because they are out of the range of possibility, as would be the case if the market had no saturation point and we wanted to maximize profits. Regardless of the context, then, the problem must be carefully crafted to involve a plausible use of the tools available. This being said, we have found that a powerful motivator comes from the computer-gaming crowd: When they are given a nonlinear regression model by the computer and told it is possible to do a better job describing/fitting the data by including horizontal sifts or scaling the function appropriately, many students invest considerable effort, even though the realism of the situation is minimal.

The process of framing authentic problems offers a challenge that is very different from the challenges typically faced in writing mathematical exercises. Authentic problems must be posed so that students see it as authentic while simultaneously remaining vague in its statement and definition to maintain realism. After all, the CEO will probably not outline particular mathematical tools, like multivariable regression analysis or time-series forecasting, that may be useful in a project; it's the employee's job to determine these. At the same time, instructors need to provide some guidance to students on how to approach the problem. After all, the students are in college to learn how to approach real world problems, not to be tested on their ability to solve them up front. The rhetorical context of the memo problem mitigates this tension. One can present a real world problem while still providing some initial filtering and set up. The key is not to set up the model world for them: the memo should help them bridge the gap between the

world of the real problem and the world of the mathematical model. As mathematicians, we often focus on the mathematics, rather than the mathematization, offering students problems with detailed sub-steps that will guide them to the solution. This is the opposite of authentic assessment, in some sense. And while students need guidance in the process, there are ways to provide this without an elaborate formulation of the task with lots of guiding questions. A better approach, according to (Blomhoj & Jensen, 2003) is through the use of dialogue. Above, we have discussed a slightly different approach, the use of rubrics or COGS-type matrices followed up by class discussions. Notice that we provide this matrix of problem components *after* students have struggled with the problem. Giving them the entire list what could be in their solution up front is overwhelming and circumvents the process of letting them come to their own solution.

Evaluating student work on memo problems in this way prevents students from simply reproducing procedures; they must find analytical tools to apply to the situation. Students are not blindly casting about for such tools, though, since they have clues outside the memo itself about what techniques are likely to be useful. After all, if the memo is assigned after discussion of chapter X, it is likely that chapter X will play an important part in the analysis. By thinking for themselves about how that chapter could apply they learn additional "non-mathematical" skills. Boaler (2001) refers to these as the set of practices that students learn in addition to the mathematical content. Regarding the learning of practices in a non-modeling environment, she says, "If students only ever reproduce standard methods that they have been shown, then most of them will only learn that particular practice of procedure repetition, which has limited use outside the mathematics classroom." The repetition in modeling comes not from repeating the same mathematical procedures, though. Instead, students are repeating a thought process –

analyzing the problem, developing a plan, implementing the plan, and evaluating and interpreting the results.

It is also helpful to maintain some common contexts if there will be several memos in a course. This way, students can feel that they are progressing along the ultimate solution of a particular problem and not have to start at square one in their understanding of each context, which can be quite time consuming and difficult. One must also recognize that far fewer memo-type problems can be completed in a course. Students can complete tens of template-type word problems or hundreds of straightforward procedural problems in a week of classes, but in our course, students complete one memo per week; student work runs an average of five or six typeset pages (including graphs and charts) to adequately address the complexity of the problem. This means that either the students must have a chance to practice many of the mathematical procedures in class or students must complete work in addition to their memos each week.

8. CONCLUSION

In summary, we have demonstrated a way to reorganize freshman business mathematics courses. Rather than being a class where students learn a large collection of procedures that are, to their current thinking, unrelated either to each other or to their future in the business world, the key is to develop authentic problems for students to investigate. We have framed our problems in the form of business memos, placing students in the roles of consultants working on real projects that are data-driven and require the integration of writing, mathematical procedures, technology skills, and analytical thinking. These modeling problems allow students many solution paths, so instructors must provide evaluative, critical feedback to help students re-think the problem; indeed, revision of student work has often been cited as the most important part of learning in the course. Such a process is clearly a constructivist framework for teaching, where the instructor's

job is to evaluate each student's work, providing them with feedback to help them develop deeper analytical skills using mathematics.

Developing problems for such a learning environment is challenging. The framing of the memo problems into a common rhetorical context that is realistic requires effort, but students respond to such problems with more enthusiasm than they demonstrate while working on more traditional word or drill-and-kill problems. Our students report learning a great deal from these memo problems, but only when the feedback and evaluation of student work supports the variety of student strategies for solving them and reporting them. Thus, instructors planning to develop such projects for their courses must remember three things. Subtle nuances about the design and framing of the problem can significantly alter the simplicity of a memo problem as well as its perceived realism. Feedback must be provided in such a way that when students revise their work, they are forced to genuinely reflect on it, rather than simply changing what the instructor marks as incorrect. Finally, the constructivist philosophy embedded in such assessment projects requires that the instructor give up the role of passing information to the learner, and instead provide support, in the form of examples, targeted feedback, or other tools so that learners may experience the entire process of problem solving and genuinely learn from it.

REFERENCES

Albright, S., Winston, W. & Zappe, C. (2002). *Data Analysis and Decision Making with Microsoft Excel*. Albany, NY: Duxbury.

Blomhoj, M. & Jensen, T. (2003). Developing mathematical modeling competence: conceptual clarification and educational planning. *Teaching Mathematics and its Applications*. 22(3): 123-139.

Boaler, J. (2001). Mathematical modeling and new theories of learning. *Teaching Mathematics and its Applications*. 20(3): 121-128.

CUPM: Committee on the Undergraduate Program in Mathematics of the Mathematical Association of America. (2004). *Undergraduate Programs and Courses in the Mathematical Sciences: CUPM Curriculum Guide 2004.* Mathematical Association of America: Washington, DC. Available online at http://www.maa.org/CUPM/

Dias, A. (2006). A student's modeling of a business problem: a case representative of students' struggle to see meaning in mathematics. *Teaching Mathematics and its Applications*. 25(3): 105-108.

Falsetti, M. & Rodriguez, M. (2005). A proposal for improving students' mathematical attitude based on mathematical modeling. *Teaching Mathematics and its Applications*. 24(1): 14-28.

Green, K. (2002). Creating successful calculus writing assignments. *PRIMUS: Problems, Resources, and Issues in Mathematics Undergraduate Studies*. 12(2): 97-121.

Green, K. & Emerson, A. (2007). A new framework for grading. *Journal of Assessment and Evaluation in Higher Education.* 32(4). (In process).

Guskey, T. (2002) Computerized gradebooks and the myth of objectivity. *Phi Delta Kappan*. June 2002, 775-780.

Nyman, M. and Berry, J. (2002). Developing transferable skills in undergraduate mathematics students through mathematical modeling. *Teaching Mathematics and Its Applications*. 21(1): 29-45.

Van Dooren, W., De Bock, D., Hessels, A., Janssens, D. & Verschaffel, L. (2005). Not everything is proportional: effects of age and problem type on propensities for overgeneralization. *Cognition and Instruction*. 23(1): 57-86.

Wiggins, Grant. (1998). *Educative Assessment*. San Francisco: Josey Bass.

Figure 1. The initial case study. Taken from Albright, Winston, Zappe (2002), page 30.

Entertainment on a Cruise Ship

Cruise ship traveling has become big business. Many cruise lines are now competing for customers of all age groups and socioeconomic status levels. They offer all types of cruises, from relatively inexpensive 3-4-day cruises in the Caribbean, to 12-15-day cruises in the Mediterranean, to several-month around-the-world cruises. Cruises have several features that attract customers, many of whom book 6 months or more in advance: (1) they offer a relaxing, everything-done-for-you way to travel, (2) they serve food that is plentiful, usually excellent, and included in the price of the cruise, (3) they stop at a number of interesting ports and offer travelers a way to see the world, and (4) they provide a wide variety of entertainment, particularly in the evening.

This last feature, the entertainment, presents a difficult problem for a ship's staff. A typical cruise might have well over a thousand customers, including elderly singles and couples, middle-aged people with or without children, and young people, often honeymooners. These different types of passengers have varied tastes in terms of their after-dinner preferences in entertainment. Some want traditional dance music, some want comedians, some want rock music, some want movies, some want to go back to their cabins and read, and so on. Obviously, cruise entertainment directors want to provide the variety of entertainment their customers desire-within a reasonable budget-because satisfied customers tend to be repeat customers. The question is how to provide the right mix of entertainment.

On a cruise one of the authors and his wife recently took, the entertainment was of high quality and there was plenty of variety. A seven-piece show band played dance music nightly in the largest lounge, two other small musical combos played nightly at two smaller lounges, a pianist played nightly at a piano bar in an intimate lounge, a group of professional singers and dancers played Broadway-type shows about twice weekly, and various professional singers and comedians played occasional single-night performances[4] Although this entertainment was free to all of the passengers, much of it had embarrassingly low attendance. The nightly show band and musical combos, who were contracted to play nightly until midnight, often had less than a half dozen people in the audience-sometimes literally none. The professional singers, dancers, and comedians attracted larger audiences, but there were still plenty of empty seats. In spite of this, the cruise staff posted a weekly schedule, and they stuck to it regardless of attendance. In a short-term financial sense, it didn't make much difference. The performers got paid the same whether anyone was in the audience or not, the passengers had already paid (indirectly) for the entertainment as part of the cost of the cruise, and the only possible opportunity cost to the cruise line (in the short run) was the loss of liquor sales from the lack of passengers in the entertainment lounges. The morale of the entertainers was not great-entertainers love packed houses-but they usually argued, philosophically, that their hours were relatively short and they were still getting paid to see the world.

If you were in charge of entertainment on this ship, how would you describe the problem with entertainment: Is it a problem with deadbeat passengers, low-quality entertainment, or a mismatch between the entertainment offered and the entertainment desired? How might you try to solve the problem? What constraints might you have to work within? Would you keep a strict schedule such as the one followed by this cruise director, or would you play it more "by ear"? Would you gather data to help solve the problem? What data would you gather? How much would financial considerations dictate your decisions? Would they be long-term or short-term considerations?

[4] There was also a moderately large on board casino, but it tended to attrac;t the same people every night, and it was always closed when the ship was in port.

Figure 2. Errors and point values for initial version of assignment (worth 10 points).

Points	Error in the paper
-1	Grammar and mechanics errors
-2/-1	No summary/poor summary
-1	Does not answer all questions
-1	Conclusion does not state plan and potential gains
-1	Not typed
(-1)	No clear plan stated to collect data
-1	No explanation of how they will decide if their image of the problem is "correct"
+1	Particularly unique ideas
-2	No conclusion
-2	Not a report
-2	Too vague

Figure 3. Fall 2000 and Spring 2001 student scores on case study from figure 1.

Grade	Fall 2000	Spring 2001
10	0	0
9	5	2
8	3	0
7	4	5
6	1	1
5	3	0
4	1	11
3	1	0
2	2	0
1	0	0
0	0	3 (did not submit)
Count	20	22 (19 submissions)
Mean	6.45	4.68 (5.42)
St. Dev	2.35	2.55 (1.84)
First Quartile	5	4
Median	7	4
Third Quartile	8	7

Figure 4A. Memo for final form of the case study.

Oracular Consulting

Memo Problem 1

To: Analysis Staff

From: Director of Marketing

Date: August 15, 2013

Re: Salena Way RFP

I have received an RFP (Request For Proposal) from Salena Way, Director of Carnivorous Cruise Lines. Her RFP is enclosed in hard copy and also attached electronically.

After you read and think about Ms. Way's problem, I want each of you to send me a memo of a preliminary proposal to deal with it. I will give you some feedback and you can resubmit your revision to me (I will post the deadlines on our intranet web site). I will then pass on your revised proposal to our marketing team, who will cost it out. I will write a cover letter and submit the final proposal to Ms. Way myself.

Our marketing team will need your proposal to include the following, so make sure you address each of them:

1. What is the perceived problem(s) and its consequences?

2. Possible reasons for the problem (The RFP suggests three possibilities. Make sure you address these and maybe consider one or two other possibilities).

3. A plan for gathering data to help identify the problem. You need to include a rough timeline for the whole data collection and analysis process.

4. Use your possible reasons and possible solutions (1 and 2 above) as a way of ensuring that your data collection gets you what you might need; that is, use these as a reality check to refine your thinking.

5. Identify any possible difficulties, problems or expenses (there will indeed be some) that might be encountered in collecting and analyzing such data. Don't include any dollar figures because our marketing team will do this.

Figure 4B. RFP for final form of the case study.

REQUEST FOR PROPOSAL

From: Salena Way, Director of Carnivorous Cruise Lines
To: Director of Marketing
Oracular Consultants

As you may be aware, cruise ship traveling has become big business. Our cruise line is now competing for customers of all age groups and socioeconomic status levels. We offer all types of cruises, from relatively inexpensive 3-4-day cruises in the Caribbean, to 12-15-day cruises in the Mediterranean, to several-month, around-the-world cruises. These have several features that attract customers, many of whom book 6 months or more in advance: (1) they offer a relaxing, everything-done-for-you way to travel, (2) they serve food that is plentiful, usually excellent, and included in the price of the cruise, (3) they stop at a number of interesting ports and offer travelers a way to see the world, and (4) they provide a wide variety of entertainment, particularly in the evening.

This last feature, the entertainment, presents a difficult problem for our ship's staff. A typical cruise might have well over a thousand customers, including elderly singles and couples, middle-aged people with or without children, and young people, often honeymooners. These different types of passengers have varied tastes in terms of their after-dinner preferences in entertainment. Some want traditional dance music, some want comedians, some want rock music, some want movies, some want to go back to their cabins and read, and so on. Obviously, our cruise entertainment director wants to provide the variety of entertainment our customers desire within a reasonable budget because satisfied customers tend to be repeat customers. The question is how to provide the right mix of entertainment.

As a part of an internal quality control study my department has been conducting, I recently took one of our 12-day cruises. The entertainment seemed to be of high quality and there was plenty of variety. A seven-piece show band played dance music nightly in the largest lounge, two other small musical combos played nightly at two smaller lounges, a pianist played nightly as a piano bar in an intimate lounge, a group of professional singers and dancers played Broadway-type shows about twice weekly, and various professional singers and comedians played occasional single-night performances. (There is also a moderately large onboard casino, but it tended to attract the same people every night and it was always closed when the ship was in port.) Although this entertainment was free to all passengers, much of it had embarrassingly low attendance. The nightly show band and musical combos, who were contracted to play nightly until midnight, often had fewer than a half dozen people in the audience – sometimes literally none. The professional singers, dancers, and comedians attracted larger audiences, but there were still plenty of empty seats. In spite of this, the cruise staff posted a weekly schedule, and they stuck to it regardless of attendance. In a short-term financial sense, it doesn't make much difference. The performers get paid the same whether anyone is in the audience or not, the passengers have already paid (indirectly) for the entertainment part of the cruise, and the only possible impact on our cruise line (in the short run) is the considerable loss of liquor sales from the lack of passengers in the entertainment lounges. The morale of the entertainers was not great – entertainers love packed houses (and so do we at Carnivorous!). Of course, as they usually argue somewhat philosophically, their hours are relatively short and they are still, after all, getting paid to see the world.

We need to get to the bottom of this. Off the top of my head, could it be that we have a problem with deadbeat passengers, or low-quality entertainment, or a mismatch between the entertainment offered and the entertainment desired? How do I go about finding out? Should we keep a strict schedule, or should we play it more by ear? We need a proposal that identifies the problem(s) and then offers a solution(s) within a reasonable time frame for a reasonable price. (Adapted from Data Analysis and Decision Making with Microsoft Excel by Albright, Winston, and Zappe, Duxbury Press, New York, 1999)

Figure 5. Comparison of characteristics of authentic assessment from Wiggins (1998, pp. 22-24) and the memo problems discussed herein.

Authentic Assessment Indicator	Our memos
is realistic	Memos and reports are common forms of business communication; students use common business tools (spreadsheets) in their analysis
requires judgment and innovation	Most memo problems have multiple solutions and paths, requiring students to evaluate possible choices and weigh the consequences
asks the student to 'do' the subject	Students are not merely calculating statistics or pushing symbols to prove they can; they need to use these skills in order to support their analysis of the situation
replicates or simulates the *contexts*	We have worked hard to pick realistic scenarios from business, guided by existing case studies for business teaching
negotiate a complex task	None of the memos are one-step problems; all involve multiple steps, each which affects subsequent steps of the solution
allows appropriate opportunities	Revision is a key component of the memos; students receive feedback in the form of a COGS matrix (Green & Emerson, 2007)

Figure 6. Memo assignments throughout the course. Students typically complete ten of these. The memos, data files, and COGS-rubrics can be found at under "Instructor Resources" at http://keep2.sjfc.edu/faculty/kgreen/DataAM_Web/index.htm

Chapter	Description	Focus/skills developed
1	RFP regarding cruise ship entertainment	Perceived problems, finding data in the real world
2	Collecting data from cruise ship	Types of data, organization of data, data collection instruments
3	Patterns in cruise ship data	Use of mean, standard deviation, z-scores to make comparisons
4	Placement of two managers	Use of boxplots to compare data sets and draw inferences
5	Fast food service analysis	Use of histograms to identify patterns and outliers
6	Financial portfolio planning	Connections between different representations of data
7	Trucking fleet analysis	Correlation, trends, and slope
8	Commuter rail system projections	Development and use of linear regression models
9	Gender discrimination (in salaries)	Development and interpretation of different models (multivariable and categorical data)
10	Truck fleet analysis	Multivariable analysis with ANOVA and other parameters for goodness of fit
11	Beat the computer's model	Using shifts and scaling to better fit nonlinear, bivariate data
12	Insurance cost analysis	Multivariable linear and nonlinear model building, interpretation and comparison
13	Revenue and demand relationships in substitute commodities	Multivariable quadratic models
14	Profit maximization	Building nonlinear models and locating extreme points several ways
15	Loan comparisons	Interest rates and future values