Assessment of a New American Program in the Middle East

Thomas W. Rishel
Weill Cornell Medical College
Doha, Qatar
rishel@math.cornell.edu

Abstract. This paper provides an assessment of a new American-style program in a medical college in the Middle Eastern nation of Qatar. It includes a consideration of the appropriateness of the mathematical curriculum to Middle Eastern students and to a medical program; an evaluation of examinations and projects with respect to critical thinking; and a post-semester student survey to ascertain further needs. Conclusions apply both specifically to this program and generally to how mathematics fits into all medical education.

Background

In August 2002, Cornell University took the daring, unusual, and in some circles controversial step of opening a branch campus of its medical school in the city of Doha in the Middle Eastern nation of Qatar. About 790,000 people live in the country, almost all of them residing in the city of Doha itself. A few other towns in the Connecticut-sized nation support either the fishing or the liquid natural gas industry. Eighty percent of the residents of Qatar are from outside the country ("ex-pats"). Most come from the Indian subcontinent, with other residents from the Philippines, Malaysia, Egypt, Syria and Lebanon, and some from Europe and the Americas.

An Emir, His Highness Sheikh Hamad bin Khalifa al-Thani, governs Qatar. A new constitution has just been approved which supports a parliamentary form of government, and all Qatari citizens will be eligible to run for and to elect the parliament. The Emir's wife, Her Highness Sheikha Mozah, is the director of the Qatar Foundation for Education, Science and Community Development, a private foundation established in 1995 that has invited Cornell to found our medical college in Qatar.

Assessment of Candidates for Admission

As an essential condition of its involvement in the WCMC-Q project, the Cornell administration requires that all students at the Doha campus receive a "full Cornell education." Thus the program is designed as a six-year premedical and medical education, from freshman to medical doctor, with criteria and standards equal to those asked of students in the United States. Students are selected by the Cornell admissions office, not through the Qatar Foundation. SAT and TOEFL scores comprise a large part of the criteria. Further, a candidate's enrollment in the undergraduate program does not guarantee automatic admission to the graduate medical school; every candidate must pass another rigorous second-year review by a separate admissions board, which will assess undergraduate grades and scores on the MCAT.

Most of the students come from outside the United States; hence admissions folders need to be "translated" between nations. For instance, many schools in Lebanon follow a French-style tradition, while those in Kenya have a British curriculum. One effect of these differences is that WCMC-Q has hired an admissions officer with extensive experience in international medical education. Another is that most faculty members are now quite involved in the admissions process. The pre-interview of candidates becomes an important determiner of admission, and we therefore have designed a variety of questions specific to determining whether individual students will be successful in the program.

I met with four candidates the first year; this year, I have seen five more. In each interview, my questions have to do with previous experience, especially in science; about any work experience they may have had, especially in hospitals or clinics; about the types of medicine that interest them; and about how they see themselves attaining their goals over the next few years.

Numbers. In the first year, WCMC-Q offered admission to thirty students. Twenty-six arrived. One student, a Qatari, was offered late admission to a medical school outside the country; he chose to leave WCMC-Q during the third week of class. Since then we have not lost any more students.

The Original Plan

When I was hired to teach calculus at WCMC-Q[1], I was given two not quite overlapping, perhaps contradictory, goals:

- Replicate the traditional Cornell curriculum in mathematics,
- Add to that program according to the medical education and cultural needs of the students.

In considering the above, I decided that the second of the two charges was the more pertinent. My reasoning was as follows:

First, Cornell has no premedical major, as such. Students who wish to go on to medical school major in biology or chemistry—or philosophy, say, or mathematics. Thus, strictly speaking, Cornell has no fixed "calculus for medicine" or "calculus for biology" courses. The course I was asked to teach is called "Math 106: Calculus for the Social and Life Sciences" at the Ithaca campus, renamed Math 104 for Doha.

Second, the text for the course is one that includes some problems from the life sciences, but these problems are usually ones designed to fit the topic being taught. For instance, in a chapter on derivatives of polynomial functions, one of the problems might ask students to graph a cardiac output function:

$$g(x) = -0.006x^4 + 0.140x^3 - 0.53x^2 + 1.79x,$$

then use the derivative to find the maximum cardiac output. While it is worthwhile to get students thinking that derivatives of polynomials might have some use in measuring cardiac output, no significant discussion was spent on why such a function really related to actual cardiac activity. Thus I decided that if I were to really make the course relevant to the future needs of the students, I would have to find and discuss "real world" examples from biology and medicine. Of course, this could be a dangerous course of action for me given what I know about biology and medicine.

Assessment I — Change on the Run

Math 106 is a basic course in calculus that attempts to incorporate a large number of topics into one semester. The course begins with an algebra review, followed by introductory differential and integral calculus, including word problems and computations of areas and volumes. It then has a touch of partial derivatives, and finishes with two weeks worth of differential equations. (My syllabus is posted as Appendix A in the web version of this report.[2]) In the absence of any experience with students at WCMC-Q, or in the Middle East, I decided to use the main campus' Math 106 syllabus as my benchmark, and especially not to skip the algebra and trigonometry review. I soon found, however, that only one of our students could have been termed deficient in those skills. Of course, by the time I had realized this, we had already gone through five class days of discussion of functions, polynomials, logs and exponentials.

When we reached topics in differential calculus, the students again assured me that they had "seen it all." I am used to this reaction, however. In my twenty-seven years at Cornell's main campus, it almost always turned out that each student had seen about 50% of the material. However, each had seen a different 50% at a different emphasis with easier exercises and probably without word problems or related rates problems. This time, my assumption proved correct; this material and subsequent topics proved to be the proper mathematics at the proper pace.

There was another even more important reason for teaching the standard college-level course at the standard rate. As I soon learned, students at WCMC-Q came from a background where quick recall of factual information was central to the educational process; in fact, that often appears to be the entire educational process. Thus it was often necessary for me to emphasize the concepts of calculus, the "Why does this work?" aspects, rather than just teaching "How to solve it" over again. Let me add here that most students at the main campus exhibited the same behavior—it was just more noticeable here in Doha.

---

[1] I use the first person throughout. With the exception of a teaching assistant, I am the entire Department of Mathematics — for better or worse. Faculty meetings are easy.

[2] www.maa.org/saum/cases/WeillMed-A.html

As the semester progressed, I did make a number of changes, not in the material itself so much as in the ways in which I approached it. Among these changes:

- Additional examples from biology, chemistry and physics.
- A slightly different style for examinations.
- More quizzes and oral work.
- Some changes in the "Math Review" sessions (as explained below).
- A final project as an alternative to the final exam.

To expand on each of these topics:

My additional examples often came from textbooks like those of Adler [1] and Edelstein-Keshet [4]. A few others were mathematical expansions of discussions from the instructors in the biology, chemistry, and physics courses that I attended. I found it invaluable to see how mathematics is actually used in the biology or chemistry classrooms, and I highly recommend that pre-medical and medical faculty collaborate this way.

I also adapted materials from some "biology and mathematics" web sites. Many of these examples needed to be revised for the audience, however, either because they deleted much of the mathematical aspects of the topic or because they brought in methods that are too advanced for the students' level. I also included a number of biological examples in the differential equations notes that I wrote for the last two weeks of the course. A reference to these notes is in the bibliography [7] and I can send them on request.

My lectures and examinations also changed in that I occasionally offered examples concentrating on the conceptual aspects of topics,and asked questions based on the above examples. For instance, in one examination I proposed a mathematical model for neuron activity and then asked the students to use it to find the maximum ratio of axon to sheath in this model.

A second method I used on examinations was to give multi-part questions whose last part or two asked students to answer questions like "What should this look like?" "Is the model realistic? Why or why not?" "What does the mathematical answer from the previous part of this problem mean to a biologist?" "How do you interpret the graph?"

I gave more quizzes in class because I found out that the typical WCMC-Q students were strongly inclined to operate in strict crisis mode; that is, they would study mathematics only during the week that the exam was coming, then completely ignore my subject until the week of my next exam. (I will say more about this in the "cultural cues" section coming up.) Unfortunately, I didn't rediscover the usefulness of frequent quizzes until late in the semester, but I won't forget for next year's class.

Differential Models of Tumor Growth and Repair
Measurement of Cardiac Output Using the Dye Dilution Method
Calculus and Chemical Kinetics of Reactions
Something About Dialysis
Autoimmune Diseases: Systemic Lupus Erythematosis
Enzymatic Reactions
Exponential and Differential Equations of Tumor Growth and Cure Probabilities
Poiseulle's Law
Oral and Intravenous Drug Intake
The Nitrogen Washout Technique for Pulmonary Function
The Shuttle Problem

Figure 1. Final Projects

There are a number of research papers supporting this strategy. Frequent testing has many important benefits for the learner, in that it encourages regular study habits and decreases cramming. For details, see references [3] and [6]. Test anxiety is reduced, according to [3]. Further, research shows that students favor frequent testing [2], and that these frequent tests also consolidate learning [3]. Finally, a study by Spitzer [9] shows the beneficial effects of giving examinations very soon after instruction.

When I was at the main campus in Ithaca, I found that my Sunday evening "Math Review" study halls were extremely popular with students. (For more detail on these, see Lewin and Rishel [5].) At WCMC-Q, however, with students in "crisis mode" all the time, I found that most were unlikely to use these sessions in the intended manner. Thus, I have decided that in the coming year I will use these periods for algebra and trigonometry review in the first few weeks, followed with some additional material on statistics. Only during examination weeks will I use these sessions as real review for the current calculus materials.

About eight weeks into the semester, I decided to offer the students the option of a final project as an alternative to the final examination. The project was described as a roughly five-page paper on a topic from biology or chemistry using significant mathematics from the calculus course. Twelve students opted for projects; some topics are listed in Figure 1.

Students who chose projects did so for a variety of reasons: "It will be more interesting, challenging, relevant to medicine." "I need to learn how to write papers." "I'm better at writing than math." Those who opted for the exams said: "It will be shorter/take less time to prepare." "I've been doing well at exams; why change now?" "I started to do a project, but it was taking too much time." "I just couldn't get my act together."

From my perspective, the papers took a great deal of time. For instance, when the students found out that I was coming to school at 7 AM, they started to do the same to "talk to me about the project." This was very nice, of course, but it also meant that I could no longer do some of my other work at school, even on weekends.

In investigating final grades, I found that they averaged to the same letter grade regardless of whether students took the examination or did the project, in the following sense:

- The 13 students who took the exam averaged B for a final grade.
- The 12 students who wrote projects averaged B for the final grade.
- While some individual student grades on final projects deviated up or down one letter grade from prelim grades, the same was true for the students who took the final exam.
- The final examination changed seven of the thirteen grades; four went up, three fell.
- The final project changed five grades; four rose, one fell.

The last two bullets merit more reflection. Changes in grade could have reflected grading policy, or they could have been caused by the students' desire level. Perhaps those who chose projects put more effort into their work, either because they were interested in it or because they actually did write better. Or maybe those who chose final exams did so because they thought the test would be easier, and then they didn't work as hard. Which possibility is correct? I think it's a combination.

Assessment II — Factoring in Conceptual Knowledge

Upon discovering the students' relative weakness in conceptual knowledge, I revised the curriculum and examinations to place more emphasis on conceptual knowledge of calculus. A sense of my approach to lectures can be obtained from my differential equations notes [7].

I also compared student grades on "factual" versus "conceptual" questions on my examinations. The student average on conceptual questions was 64%; that on factual information was 65%. Of course, again there were open questions. Who decided what a conceptual question was? Well, I did, based on using Benjamin Bloom's model of cognitive levels. Bloom's model is fairly well known in educational circles, less so in mathematical ones; for some details on this model and how I use it in mathematics, look at chapter 27 of my text [8].

Another question: Who graded these exams, and was the grading uniform?

Answer: My TA and I graded all exams, and the grading was "uniform by question"; i.e., he would grade all responses to a particular question, I would grade all of another.

A third question: Were students primed for specific conceptual questions, or were the problems ones they hadn't seen before?

Answer: These were new problems, although of course students needed to use mathematical methods that had been discussed in lecture beforehand.

A final question: What was the relative amount of conceptual questioning?

Answer: Only about 10% of all the examination material was conceptual in nature. This was partly because I didn't arrive at this methodology until the semester was about six weeks old, after the first examination. I will give more conceptual material next year, but will still include only about 20%.

A Cultural Cue

During the second semester, when I was not teaching, two students provided the physics instructor a strong cue as to one of the differences between Middle Eastern and American education and its impact on student development.

One of the students asked the physics instructor, Marco Ameduri, not to show her the grade on her third exam. "I know I did badly," she said, "I just don't want to see the exam." In discussions on this case, Marco and I agreed that he should tell her that she needed to see where she had gone wrong in order to get it right for the final exam. The next time he saw the student, he told this to her. Her response was not what either of us expected, however. "I know perfectly well what I did incorrectly," she responded. "That isn't the reason I don't want to see the exam. The reason is that I am used to having exams that are based totally on memorization, and whenever I see the problems during the test, I immediately try to remember which homework problem it was. It will not be necessary to see the test."

A second student who started slowly in my course confirmed this phenomenon. She came to me to discuss some causes of her improvement. I paraphrase what she said:

When I used to get an exam problem, I would try to remember all the homework, all the lectures, and all the examples I had ever seen. There was so much to think of and remember that it just got confusing. After some bad exams I realized that any problem I would see on the exam wasn't going to be one I had seen before; it would be new, and I would have to solve it from first principles. That was actually easier. I still fall back, however, into the behavior I've been trained to use; I have to consciously remember not to do that.

The above student examples indicate that, even though there are students outside the Middle East who try what might be called the "mental rolodex" method of solving science and mathematics problems, here in Qatar the quick recall of factual information type of examination is so pervasive that these students must be repeatedly and actively discouraged from using it.

Of course, this may bring with it another problem. We are dealing here at WCMC-Q with a group of students who have been extremely effective in the "rolodex" method; to change now could lead to a certain amount of resentment. How this last is handled will be a further question for all faculty to consider.

I will continue to explore cultural cues to pedagogy as my tenure here at WCMC-Q continues.

Assessment III — The Survey

No assessment paper is complete without a student survey. Mine is found in Appendix C of the web version of this report. [3] Here I will offer an analysis of the results.

I did not give this survey until late in the following semester, in April 2003, to give students time to think about whether the mathematics course had been useful. In fact, this last was my first question.

Findings from the survey:

- The only topics that any of the students mentioned as being difficult were word problems and the final differential equations section. No one advocated dropping either, however, and in fact, they all said these were the most useful of the topics they studied. Two students proposed that I simply spend more time on the differential equations section; this looks like an excellent solution to the problem.
- Some students suggested that I collect homework assignments. I think that instead my approach will be to often ask one of "last night's problems" on quizzes.
- They especially liked the real world applications. No one suggested that I do fewer; many asked for more. Many students mentioned "applicability to biology and medicine" as being important in making the mathematics relevant to their experience. "Having problems that are not in the book and then try[ing] to solve them in recitation and then seeing more applications will…make [the course] more interesting."
- Only two students suggested that I add any new topics to the course: Taylor series and line integrals. One of those two students mentioned that the mathematics I taught fit very well with the physics course, which is "all about derivatives and integrals. Therefore, mathematics has definitely helped us throughout the physics course."
- The students said that there were enough homework problems, and at the proper level. One student suggested that I should make them do the homework by having them "handed in by the students and checked even if not graded."
- Everyone concluded that the examinations were fair and no substantive suggestions for changes were made.
- Although they found the lectures and differential equations notes useful, they were not as enthusiastic about the recitations or the math reviews. Sherwood's lectures were popular, however. (Sherwood is my teddy bear; he gave two guest lectures: one on mechanics of the heart, one on an ecological problem.)

The question that elicited the longest responses was the one about whether their general reasoning skills improved. Everyone responded with an unqualified yes—but all with somewhat different reasons. "My logic has certainly evolved…since medical and biological examples were given," said one. "I liked the questions where we were interpreting the graphs. I think that improved my 'readings' of graphs," said a second. "Yes, due to the applications we were taught," was a third response.

A final comment about the survey:

An underlying theme of the responses was "we wanted you to work us harder. We wanted more homework problems; we wanted more and harder quizzes; we wanted to have more biological problems to take home and try; some of us even wanted a couple more topics in the lectures." [This is not a direct quote; rather, it's a pastiche I have drawn up from the sense of what I heard from the surveys.] Given that I assigned approximately three times as many homework problems as would be assigned in Ithaca, that I covered much more material in differential equations than the students would ever see there, and that I assigned a very labor-intensive final project, I find that most remarkable.

Uses of the Findings

Many changes have already been described, but I will summarize them here.

Rather than discussing algebra and trigonometry formally in the main lectures, I will give a diagnostic on day one and offer review sessions on the first two Wednesdays. At the end, I will carve out extra days for a more careful discussion of differential equations; but I will not add more topics to this section.

Some statistical topics will be added, including a short discussion of hypothesis testing and regression. The reason

[3] www.maa.org/saum/cases/WeillMed-B.html

is that it could be argued that for a doctor an understanding of statistical methodology is at least as important as a sense of how calculus applies to medicine. (I myself would argue that both are essential.) To find time for statistical topics, I will replace last year's algebra review as well as some of the Math Review time.

Biological and chemical examples will be present from the start. This will be easy enough to do if I begin with logarithms and exponentials. Further, my applications-oriented approach will continue all the way through differential equations.

Conceptual questions will enter in right away. "Why does this work?" "What is wrong with the following model?" I have always used quite a few questions in my exposition; even so, they will be increasing in the future.

All examinations will include some questions emphasizing higher-level critical thinking. Many short quizzes will be added, for reasons outlined in earlier sections of this paper.

Projects will continue to be used, with the goals being to enhance writing and reasoning skills, and to increase student awareness of how mathematics can be applied to science and medicine.

Subsequent Plans

Once I start teaching statistics, I will no doubt need to make further changes.

Also, as projects increase, WCMC-Q will be in need of relevant papers and journals. Students here in Qatar do not have as much access to reading materials as they do in the States, and we will have to find ways to bring these to students. Of course, such sources must be appropriate to students' levels; current research papers are unlikely to be usable. It would be wonderful if there were good access to written materials here in Doha, but unfortunately that is not yet the case.

There is a need to teach the students how to read and evaluate scientific literature. "Study skills" in the North American sense are generally low, and I cannot expect others to provide these skills to my students. To this end, I have gathered some materials on such topics as: how to manage time, read textbooks, take notes, and prepare for examinations. I may have to expand these materials.

Conclusion

Teaching at WCMC-Q has been a never-ending revelation to me. As I have mentioned to many people, Qatar is a place where I never in my life expected to go. Not only is the nation of interest to me, but also the cultural and pedagogical questions that I have encountered are ones that can only keep me intrigued for a long time. I have learned at least as much from the students as they have from me, and I have every hope and expectation that the situation will continue.

References

1. Adler, Frederick. *Modeling the Dynamics of Life: Calculus and Probability for Life Scientists*. Pacific Grove, CA: Brooks/Cole, 1998.
2. Bangert-Drowns, R.L., J. Kulik and C. Kulik. "Effects of Frequent Classroom Testing," *Jr Educ Res*, 85 (2), 89–99.
3. Dempster, F.N. "Using Tests to Promote Learning," *Jr Res Dev in Educ*, 25 (4), 213–217.
4. Edelstein-Keshet, L. *Mathematical Models in Biology*. Boston: McGraw Hill, 1988.
5. Lewin, M. and T. Rishel. "Support Systems in Beginning Calculus," *PRIMUS*, V(3), 275–86.
6. Mawhinney, V., D. Bostow, D. Laws, G. Blumenfeld, B. Hopkins. "A Comparison of Students' Studying Behavior Produced by Daily, Weekly, and Three-Week Testing Schedules," *Jr Appl Behav Anal*, 4, 257–264.
7. Rishel, T. *Differential Equations*. [Draft at rishel@math.cornell.edu].
8. Rishel, T. *Teaching First: A Guide for New Mathematicians*. Washington: Mathematical Association of America, 2000.
9. Spitzer, H. "Studies in Retention," *Jr Ed Psych*, 30 (9), 641–656.