Story of Math Gym

Nagaraj K. Neerchal
Professor of Statistics and Chair
Department of Mathematics and Statistics, UMBC

It was Fall 2013. Our charismatic president Dr. Freeman Hrabowski had been named one of the 100 most influential people in the world by the Time magazine. He received the Carnegie Foundation Award along with a check of $500,000. Freeman donated the prize money to UMBC to establish Hrabowski Innovation Fund to encourage innovations. The three things that Freeman often brings up in his conversations, math, healthy diet, and exercise together inspired the idea for Math Gym. It is appropriate that Math Gym was founded by Hrabowski Innovation Fund as it embodies Freeman's mantra "everyone can get better with a little bit of help".

What is Math Gym?

The Math Gym is a concept rather than an actual place. It applies the wisdom that practice is the key to learning math well. It precipitates the best practices of many excellent instructors of foundational courses from the Department of Mathematics and Statistics. The Math Gym provides a framework of connecting the practice to class work in a tangible way. The Math Gym features "conditioning coaches" and "personal trainers" who will help students keep their foundational math skills in good working order. Moreover, the gym promotes healthy math habits among all our students, drawing a clear analogy between the regular work outs and conditioning needed to maintain both athletic and mathematical skill.

The students in the Math Gym start with worksheets recommended by analyzing their state of knowledge as they enter the class. As they progress through the class, each quiz shows the level of mastery (or lack thereof) at that stage. If the mastery is not strong enough to learn the follow on material, a new set of worksheets are recommended. Students are invited to attend the Math Gym regularly to work out on the extra problems assigned to them based on what they specifically need to work on. The continuous connect between practice and class work is expected to keep motivation at a high level.

The initial assessment is known as QuizZero. Every student's need, as determined by the performance in QuizZero, is potentially unique. Hence a unique set of worksheets are designed to meet each student's need. A student entering Math Gym will sign on to a MS-ACCESS database, and it will immediately indicate the worksheets that are due and their due dates. They can start working out right away. Coaches, many of them graduate students and a few advanced undergraduates, walk around in Math Gym. A student having difficulty can raise his/her hand and flag a coach for help. The coach will look at the work and will provide just the appropriate hint to take the student over the hurdle. This is referred to as spotting, just as an athlete would need while lifting a weight that is slightly out of his/her normal lift.

The Math Gym Loop starts with the instructor who creates QuizZero, which leads to a personalized workout plan. The data base will then track the student throughout the class from one quiz to the next by way of work out sheets to reinforce the in-class lessons.

Math Gym incorporates the scalable aspects of many tried and successful ideas of excellent teachers in the Department of Mathematics and Statistics, UMBC. The path leading to the conception of Math Gym is outlined below.

Hybrid version of Math 106

I became the chair of the Department of Mathematics and Statistics in July 2006. In the second week of classes in September, a student emailed me for an appointment to launch a complaint. The student was enrolled in Math 106 and was furious. He insisted that he DID NOT belong in Math 106. He had taken algebra in his freshman year high school and never touched his algebra book since then. In fact, he referred to our method of teaching high school algebra in an excruciatingly slow pace over a semester as "…" that I cannot repeat here. After making a special arrangement for a challenge placement test for him, I wondered how many such students are there in Math 106. UMBC admits about 1500 freshman every year. Every single such student has had Algebra in High School. But, more than 750 of these students end up in our Math 106. It was clear to me that we had to provide different modes of delivering the same material so that students have an option to choose between a "quick brush up" and a "total makeover". So, we decided to offer an online section of Math 106 using a widely used Algebra review software known as ALEKS.

The purely online version of ALEKS ran into some difficulties. Students found it difficult to sustain the high degree of motivation needed to complete all assigned activities on time. Quizes, exams and projects of the other courses came in the way of keeping regular focus on Math 106. Ms. Raji Baradwaj, the online algebra pioneer of our department suggested that we augment the online Math 106 with a weekly motivational session. Hence the Hybrid version of Math 106 was born. Now we deliver Math 106 mostly in the Hybrid mode, a combination of a weekly one hour contact with the instructor accompanied by monitored in-lab exercises and homework with deadlines tied to adaptive release in course management system. We offer only a limited number of seats in the traditional version of Math 106.

QuizZero….

In the Spring 2007, our department was making some curricular changes as a response to the needs of one of client departments. Since the change was likely to affect all STEM departments, I contacted my fellow chairs to solicit input. A common complaint was that students did not retain the knowledge they acquired in the pre-requisite courses long enough to be able to use it in a follow on course. I shared my experience with my colleagues in a faculty meeting, and there was a very lively discussion. Because the sequential nature of learning, like one builds a high rise one floor at a time, is most evident in learning Math, the same was observed as students progressed from one math class to the next. I learned that

some of my colleagues were giving a "diagnostic test" at the start of every semester as a way of communicating to students what kind of skills from the pre-requisite class will be immediately needed in their class. In fact, discussing the results of this test in the first class turned out to be an excellent segway to discussion of study habits, forming study groups and so on. It seemed like a very good practice that needed to put into use more widely, especially in our foundational courses. Hence we created QuizZero.

QuizZero is administered during the last weekend before the first day of classes. Instructors of Pre-Calculus, applied Calculus, Calculus I, II and most recently III, create a battery of 25 questions designed to identify potential weakness in the student's ability to understand the material presented in the first part of the current course. The scale of the operation is enormous: Nearly 2000 students will be taking a 45 minute long test offered via Blackboard in proctored computer labs. The operation involves the instructors (designing the test), graduate teaching assistants (proctoring), department staff (booking labs), and DoIT personnel (computer labs). It is critical to complete the entire process including grading before the drop date so that students have the benefit of this information for their decision. In addition to the sheer magnitude of the task, we also occasionally face issues due to weather related closings in the beginning of Spring semesters. I am very proud to say that instructors of our foundational courses (Tighe, Stanwyck, Nanes, Dean, Baradwaj) have been strong supporters of this program. Ms. Baradwaj, who has been the QuizZero coordinator, is ably supported by the graduate teaching assistants. Since, QuizZero takes place during the week prior to start of the semester when the GTAs are already officially on payroll. Fortunately, homework assignments etc are still a week or more away, and hence we are able to redirect their effort to the QuizZero implementation during this time.

Ability of QuizZero in identifying the @risk population of Math students has been uncanny. The table below displays the strong association between QuizZero results and whether or not the students received a FYI alert. (provide a hyperlink to FYI alert in previous sentence). Only 20% of the students scoring very high in QuizZero receive FYI alerts. On the other hand the probability that a student was identified as @risk and hence received a alert based on a low QuizZero score (QZA) is about 50%. Need to define QuizZero Alert (QZA).

	FYI ALERT?		
QuizZero Alert?	**YES**	**NO**	**Total**
YES	44%	55%	1327
NO	18%	82%	1139
Total	**786**	**1680**	**2466**

If none of the students had paid any attention to QZA, we would have a significantly larger proportion of students receiving FYI in the @risk group, which is not the case. Therefore, appropriate interpretation is that while QZA seem to work well as an early warning, a large proportion of the students did not receive appropriate follow up help.

….And then there was Math Gym

It took several semesters to streamline QuizZero implementation. Along the way, it withstood snow storms, Blackboard meltdowns, locked out computer labs, schedule confusions among the graduate assistants, and at least two changes in hired helpers for Raji. Email alerts were sent out diligently with a warning that QuizZero score was a strong indicator of the success, unless remediation actions were taken. The students were directed to the variety of resources available on campus (such as LRC, MathLab) and online (Khan Academy).

One of my colleagues, Mrs. Bonny Tighe, is widely acknowledged to be the most successful Calculus instructor in our department. Her office hours are insanely popular among her students. When her office overflowed with students, she took them to the corridors, and eventually she reserved the newly built CNMS Active STEM Learning Environment (CASTLE). Unbelievably, majority of her students show up every Friday afternoon to work out Calculus problems. Bonny's initiative This program proved popular and was joined by Dr. Kal Nanes and Dr. Rouben Rostamian. Meanwhile, Dr. Liz Stanwyck, who regularly taught our Applied Calculus course (Math 155) decided to implement a "extra practice problems" to students who did poorly in QuizZero. Being a first rate statistician, she came up with a tool to map the mistakes in QuizZero to specific set of extra problems. Thus, a student who scored very low in QuizZero will have to do a lot more practice problems than someone who missed only one or two. At the end of semester, she compared the results to the performance of her students from the previous semester and observed a remarkable improvement. It seemed to me that Liz's approach is an attractive option to provide the @risk group identified by QuizZero.

The concept of a pre-test came up in a faculty meeting and it was scaled up to be the QuizZero initiative. The online component of Math Gym is inspired by our experience with hybrid mode of delivery in Raji's Math 106. The idea of supervised problem solving is inspired by Bonny's Friday afternoon sessions in CASTLE. Personalizing a set of worksheets based on the students' QuizZero performance was first tried by Liz in her Math 155. The rest of it was a matter of working out the logistics. The Hrabowski Innovation Fund gave us the necessary nudge to take the next step. Math Gym is in its third semester of existence right now, and has proven to be very helpful to students in our foundational classes.